OF 2001-6

New Nouveau
Brunswick

Natural Resources and Energy
Minerals and Energy

Open File

Geology, Development History, and Exploration Alternatives for Gypsum and Anhydrite Resources near Hillsborough (Part of NTS 21 H/15), Albert County, Southeastern New Brunswick

T.C. Webb

ISSN 1205-7150
ISBN 1-55236-773-8
Price: $14.00

2002

103-00444/

Open File 2001-6

Geology, Development History, and Exploration Alternatives for Gypsum and Anhydrite Resources in the Hillsborough area (Part of NTS 21 H/15), Albert County, Southeastern New Brunswick

Recommended citation:

WEBB, T.C. 2002. Geology, development history, and exploration alternatives for gypsum and anhydrite resources near Hillsborough (part of NTS 21 H/15), Albert County, southeastern New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File 2001-6, 47 p.

Prepared by:

Minerals and Energy Division
Department of Natural Resources and Energy
Province of New Brunswick

Hon. Jeannot Volpé
Minister of Natural Resources and Energy

March, 2002

New Nouveau
Brunswick

Natural Resources and Energy
Minerals and Energy

Open File 2001-6

Geology, Development History, and Exploration Alternatives for Gypsum and Anhydrite Resources near Hillsborough (Part of NTS 21 H/15), Albert County, Southeastern New Brunswick

T.C. Webb

ISSN 1205-7150
ISBN 1-55236-773-8
Price: $14.00

2002

TABLE OF CONTENTS

	PAGE
ABSRACT / RÉSUMÉ	v
Introduction	1
Location	1
General physical setting and access	1
Landscape features	3
General land use	5
General Geology	7
Detailed Geology	11
Deposit Type	13
Exploration and Development History	14
Exploration Model	29
Preliminary Deposit Evaluation	31
Conclusions	35
Acknowledgements	36
Bibliography	37

APPENDICES

A. Compiled chemical analysis of gypsum and anhydrite samples from the Hillsborough area of southeastern, New Brunswick (1898-1995).. 43

B. Map Plate 2000-31. Carboniferous geology and gypsum / anhydrite resources of the Hillsborough area (part of NTS 21H/15), Albert County, southeastern New Brunswick..... 47

TABLES

1. Table of formations. Summary of stratigraphic nomenclature for the Hillsborough and adjacent map areas, southeastern New Brunswick 9

ILLUSTRATIONS

		PAGE
1.	Location of Hillsborough, Albert County, New Brunswick: general land use and distribution of ("main" and "east") sulphate deposits	2
2.	Underground solution and mechanical erosion of sulphate deposits	3
3.	In the early days gypsum mining in the Hillsborough area consisted of extracting material from hillside surface exposures	4
4.	Collapse structure developed over former underground gypsum mine in the Hillsborough area.	5
5.	A network of natural "wild caves "carved out the gypsum – anhydrite deposits near Hillsborough are a favorite with amateur spelunkers and tourists of all ages	6
6.	Signature golf hole established in a former gypsum quarry near Hillsborough, N.B.	7
7.	Typical laminated anhydrite of the Upperton Formation, near Hillsborough, N.B.	12
8.	Anhydrite "cannon-ball" structures comprised of anhydrite cores surrounded by an exfoliated gypsum crust	12
9.	Typical depositional setting for primary calcium sulphate deposits	13
10.	Formation of gypsum deposits in the Hillsborough area is directly linked to active hydration fronts developed along faults and related structures	14
11.	Albert Manufacturing Company's mill, Hillsborough, N.B., 1911	18
12	(a) Typical gypsum quarry near Hillsborough, N.B, ca. 1914. (b) Opening up a gypsum quarry near Hillsborough, N.B., ca. 1917. (c) "Bringing out gypsum from [an] underground quarry," Hillsborough, N.B.	19
13.	Mill and buildings of the Albert Manufacturing Company, Hillsborough N.B., 1912	21
14.	Storage bins [silos], loading belts and shipping pier, of the Albert Manufacturing Company, Hillsborough N.B., 1930	24
15.	Albert Manufacturing Co. property changes hands	24

PAGE

16 (a) Pit-run, quarried gypsum was generally broken down by hand into smaller-sized material for easier handling. This material was loaded onto single-horse, two-wheeled scotch cart and (b) hauled to the nearest narrow-gauge railway siding 26

17. Operations of Canadian Gypsum Company, Hillsborough, N.B. (1978) 27

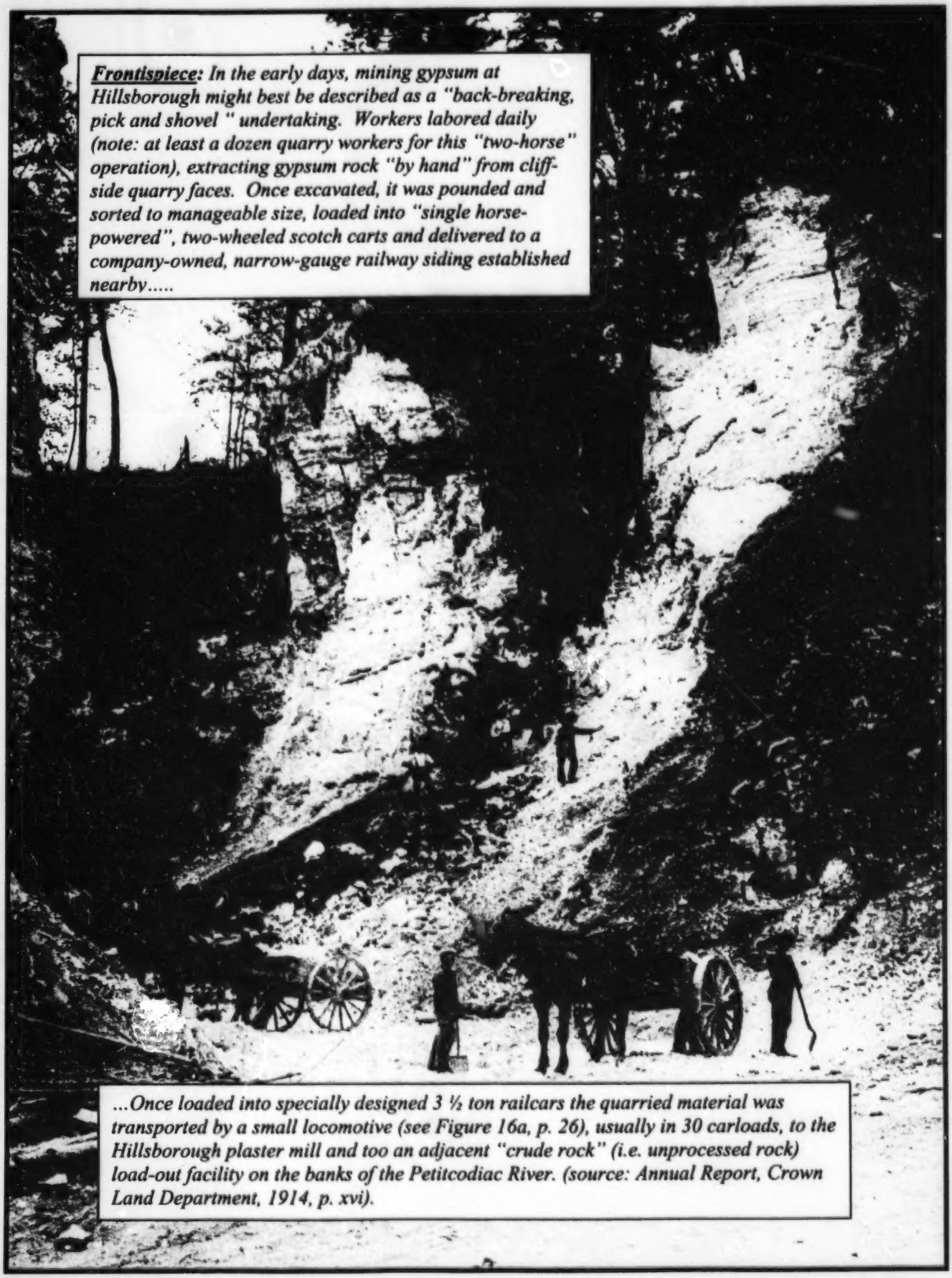
18. After a presence for over one hundred and thirty years, the Hillsborough gypsum industry is terminated 27

19. As one worker a long time ago so eloquently stated *"the [New Brunswick] gypsum deposits...are exceedingly varied in character, and in their mode of occurrence present many features of geologic interest."* 30

20. Recrystallized gypsum. Note spectacular stellate crystals of selenite in a matrix of alabastine gypsum 31

21. A drilling program (1998) has established the extent and quality of anhydrite reserves near Hillsborough, in southeastern New Brunswick. 34

22. Workman extracting gypsum from a quarry near Hillsborough, N.B., ca. 1911 35



Frontispiece: *In the early days, mining gypsum at Hillsborough might best be described as a "back-breaking, pick and shovel " undertaking. Workers labored daily (note: at least a dozen quarry workers for this "two-horse" operation), extracting gypsum rock "by hand" from cliff-side quarry faces. Once excavated, it was pounded and sorted to manageable size, loaded into "single horse-powered", two-wheeled scotch carts and delivered to a company-owned, narrow-gauge railway siding established nearby.....*

...Once loaded into specially designed 3 ½ ton railcars the quarried material was transported by a small locomotive (see Figure 16a, p. 26), usually in 30 carloads, to the Hillsborough plaster mill and too an adjacent "crude rock" (i.e. unprocessed rock) load-out facility on the banks of the Petitcodiac River. (source: Annual Report, Crown Land Department, 1914, p. xvi).

ABSTRACT

Evaporite deposits of calcium sulphate are known to extend over 230 hectares, a few kilometers west of the village of Hillsborough in southeastern New Brunswick. The Hillsborough deposits are represented by a blend of bedded primary anhydrite; secondary, massive gypsum (hydrated anhydrite); and limited quantities of recrystallized gypsum.

Recent studies suggest two sulphate units (one collapsed on top of the other) are preserved in the Hillsborough area. Together these units form a sulphate sequence several tens of meters thick. The often problematic, spatial distribution of gypsum with respect to anhydrite in the area may be related to the region's structural development. Thick deposits of high-purity gypsum (>90% $CaSO_4 \cdot 2H_2O$) are considered to be the hydration product of primary anhydrite sometimes accompanied by subsequent episodes of recrystallization that developed adjacent to and at the intersection of water-bearing fault structures.

Gypsum and anhydrite resources in the Hillsborough area have an exploration and development history that spans almost two centuries. Millions of tons of high quality gypsum have been extracted from several underground mines and surface quarries, shipped abroad in the "raw" state and manufactured into plaster of paris and related products (*i.e.*_wallboard) at a local processing facility that operated continuously for almost one hundred and thirty years. The gypsum industry at Hillsborough ended in the early 1980's.

With few exceptions, former gypsum mining and related exploration activities have been restricted to the southern part of a potentially large calcium sulphate resource area. Considering an exploration model that links the spatial distribution of gypsum deposits to fault zones there remain a few sites within the Gray Brook basin that offer possibilities for high-grade gypsum resources. One area is north of the former Tomkins quarry while another is situated immediately east and west of the former Sayre quarry and underground mining operation near the northern boundary of the basin.

RÉSUMÉ

On sait que des dépôts évaporitiques de sulfate de calcium s'étendent sur 230 hectares à quelques kilomètres à l'ouest du village de Hillsborough dans le Sud-Est du Nouveau-Brunswick. Les dépôts de Hillsborough prennent la forme d'un mélange d'anhydrite primaire litée, de gypse massif secondaire (anhydrite hydratée) et de quantités limitées de gypse recristallisé.

Des études récentes laissent supposer que deux unités de sulfate (l'une s'étant affaissée au-dessus de l'autre) ont été conservées dans le secteur de Hillsborough. Ces unités forment ensemble une séquence de sulfate de plusieurs dizaines de mètres d'épaisseur. La distribution spatiale souvent problématique du gypse par rapport à l'anhydrite dans ce

secteur pourrait être apparentée au développement structural de la région. Les dépôts épais de gypse très pur (> 90 % $CaSO_4 \cdot 2H_2O$) sont considérés comme le produit de l'hydratation d'anhydrite primaire quelquefois accompagnée d'épisodes subséquents de recristallisation survenue dans le voisinage immédiat et aux points d'intersection des structures faillées aquifères.

Les ressources en gypse et en anhydrite du secteur de Hillsborough font l'objet de travaux d'exploration et d'exploitation depuis près de deux siècles. Des milliers de tonnes de gypse de haute qualité ont été extraites de plusieurs mines souterraines et carrières de surface et ont été expédiées à l'étranger à l'état « brut » ou ont été transformées en plâtre de Paris et en produits connexes (p. ex. panneaux de revêtement) dans une usine de transformation locale qui a été en activité de façon soutenue pendant près de 130 ans. L'industrie du gypse à Hillsborough a mis un terme à ses activités au début des années 80.

Les activités antérieures d'extraction du gypse et activités connexes de prospection ont, à quelques exceptions près, été limitées à la partie méridionale d'un secteur de ressources en sulfate de calcium possiblement étendu. Vu le fait qu'un modèle d'exploration lie la distribution spatiale des dépôts de gypse aux zones faillées, quelques emplacements à l'intérieur du bassin de Gray Brook offrent encore des possibilités de ressources en gypse à haute teneur. L'un de ces endroits se trouve au nord de l'ancienne carrière Tomkins, tandis qu'un autre est situé immédiatement à l'est et à l'ouest de l'ancienne carrière Sayre et de l'exploitation minière souterraine à proximité de la limite septentrionale du bassin.

Geology, Development History, and Exploration Alternatives for Gypsum and Anhydrite Resources Near Hillsborough (Part of NTS 21 H/15), Albert County, Southeastern New Brunswick

Introduction:

Location: Calcium sulphate deposits of gypsum and anhydrite extend over a 230 hectare area, 2.5 to 4.0 km southeast of the Village of Hillsborough in southeastern New Brunswick (Figure 1). Hillsborough is a small rural community of about 1300 people, established on the west bank of the Petitcodiac River, approximately 15 km north of its confluence with Shepody Bay and 30 kilometers south of Moncton, the second largest city in New Brunswick.

From Moncton, Hillsborough is reached via a two lane connector highway, Route #114, a major coastal tourist link to the Hopewell Rocks Ocean Tidal Exploration Site nearby and Fundy National Park, 55 km further to the south.

Two decades have passed since the village's longtime gypsum mining and associated wallboard manufacturing plant; its main industry, was closed, leaving the lumber, service and small business sectors as the mainstays of its economy.

General physical setting and access: The area underlain by gypsum and related anhydrite deposits is mostly confined to a synclinal or saucer-shaped structural feature referred to as the "Gray Brook basin". With a width of 1500 m and a north-south axial trace extending over a similar distance, the basin occupies a shallow valley setting bounded by steep-sided plateau areas to the west and south that gradually reduced to a flat, marshy terrain to the east. A countryside featuring broad, rolling hills dominates the terrain to the north. Elevations in the area range from 30 to 170 m above sea level, averaging near 50 m. With the exception of former quarry sites much of the sulphate areas vegetation is reflected in a light forest cover with a mix of coniferous and deciduous tress, shrubs and other plants.

The Hillsborough sulphate resource can be geographically separated into a "main" deposit and an "east" deposit (Figure 1). The main deposit covering roughly 4 km^2, represents the most extensive resource base in the region and has been the focus of considerable mining activity for several decades. A few hundred meters to the east is a smaller, less than one square kilometer resource area. This area sustained the last operating quarry in the Hillsborough area prior to the closure of the region's gypsum industry in 1980.

The sulphate resources are accessible from the north, east and south. From the east access generally originates from the Village of Hillsborough by proceeding west on the Golf Club Road (GCR). There are several entry points along this route. One is situated approximately 1.5 to 2.0 km west of the GCR intersection with Highway #114. Just north of where

Village of
Hillsborough,
Albert County, New Brunswick

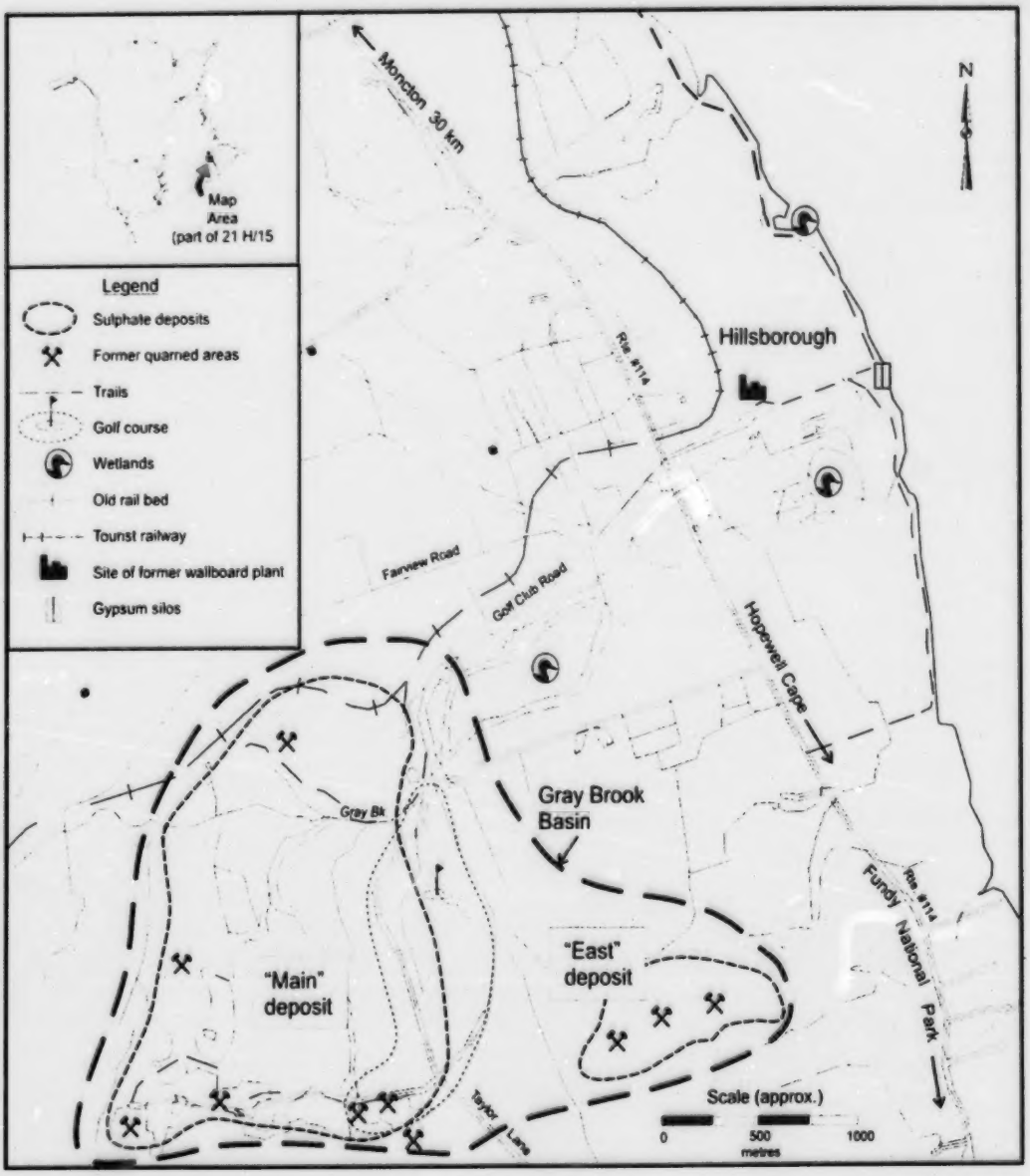


Figure 1. Location of Hillsborough, Albert County; New Brunswick: general land use and distribution of ("main" and "east") sulphate deposits.

Gray Brook crosses the CGR road an abandoned railway line bed heads westward, skirting the northern limit of the "main" deposit. Several hiking and cross-country ski trails intersect these old rail line access routes and head south into the heart of the deposit. A second access point occurs at a fork in the GCR about 1 km south of Gray Brook access point. The eastern fork leads to the "east" deposit and the former Carlisle & Marshall and King quarries. Proceeding 1 to 1.5 km further on the western fork leads to the former quarries and underground mining operations of the southern half of the "main" deposit. Several hiking and cross-country ski trails lead north from this area into the "heart" of the deposit.

The northern way into the "main" deposit is via the Fairview Road and south along several trails. The southern, developed part of the deposit can also be reached from a gravel road, leading north from the main highway (Rte. # 114) at Albert Mines.

Landscape features: In general the distribution of the sulphate resources throughout the region is displayed through the development of "natural" and what might be described as a "man-made" karstic landscape.

Karst is an irregular surface topography characterized by closed depressions called sinkholes; caves, cave systems, stream-less valleys, disappearing streams and springs (Figure 2), all developed by the action of surface and underground water on soluble rocks such as gypsum and limestone. These natural features are widespread throughout the Hillsborough area.

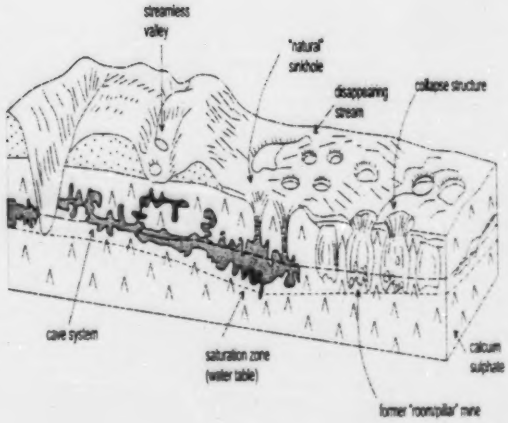


Figure 2. Underground solution and mechanical erosion of sulphate deposits produces subterranean cave networks and drainage systems, the surface expression of which is referred to as karst – a collection of unique surface topographic features characterized by dry and water-filled sinkholes, stream-less valleys, and streams that drain into the subsurface. In parts of the Hillsborough area roof collapse over former underground "room and pillar" mines is not an uncommon feature and should be respected as areas of potential ground instability.

One of the most common landscape characteristics of the area are surface depressions developed where underlying soft gypsiferous bedrock has been dissolved and abraided by waters generally unsaturated with respect to $CaSO_4$. This often results in the formation of a network of subsurface interconnected cavities of various sizes. Eventually the surface expression of these subterranean structures appear as a "sink or sinkhole" a result of structural weaknesses in overlying rock and its subsequent collapse into the cavity below forming closed depression.

Surface and related ground water may drain through these sinkholes creating disappearing streams; or if the sinks' subterranean plumbing system become clogged, they may fill with water forming small lakes and ponds, sometimes referred to as dolines or dolinas. Springs will often appear at various locations throughout the area where the underground water table intersects the land surface. In a few areas the roof collapse of interconnected cavities have led to the creation elongated, narrow solution valleys up to a few hundred meters long formed by the coalescence of several sinkholes – the White Head valley (Figure 1). This subterranean dissolution has also resulted in the local formation of caves or a network of caves that are hydrologically linked - the White Caves (Arseneault et.al. 1997)].

In some places solutioning, has proceeded to the point where sulphate residuals or stacks remain. These structures stand as closely spaced, steep-sided interconnected columns, several metres in height and diameter. Locally this landscape feature creates a very irregular and hummocky landscape making hiking in the area a rather challenging and formidable undertaking.

A second type of sinkhole-like structure is one formed as result of human activities in certain parts of the area. The gypsum deposits of the region were worked extensively for over a century providing suitable material for a nearby plaster and wallboard industry. In the early days gypsum was extracted from small quarries and through the development of fairly extensive underground "room and pillar" mines (Figure 3).

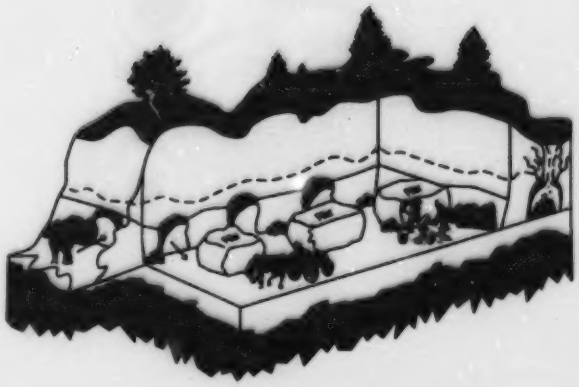


Figure 3. In the early days of gypsum mining at Hillsborough, gypsum was extracted generally from exposed hillside locations. Eventually operations were forced to expand into areas requiring the removal of several meters of overburden ("pink") to expose the sought after gypsum ("yellow"). Given the limitations of portable earth moving equipment with the capability of efficiently removing thick overburden, other methods of extraction were pursued. The massive nature and thickness of the resource made it suitable for underground mining using a basic "room and pillar" method of recovery. This mining method involved the recovery of gypsum ore with basic hand tools and "black powder" explosives from open stopes. Stopes varied in size but generally consisted of 50 to 100 m^2 rectangular rooms several meters high, with intervening, circular to square pillars of ore to support the roof or "hanging wall". Old mine plans reveal that attempts were made to arrange rooms and pillars in regular patterns.

Locally the, unstable nature of overlying "roof" rock resulted in numerous "cave-ins" and related accidents. By the 1940's mishaps were minimized

through the introduction of rock bolting, thereby reinforcing the structural integrity of the roof. With improvements to and availability of efficient earth-moving and related equipment in the aftermath World War II , underground mining practices were eventually abandoned.

Areas where underground mining was most prevalent are often characterized by the occasional roof rock collapse into underlying mined "rooms" (Figure 4).

Figure 4. Collapse structure developed over former underground gypsum mine in the Hillsborough area.

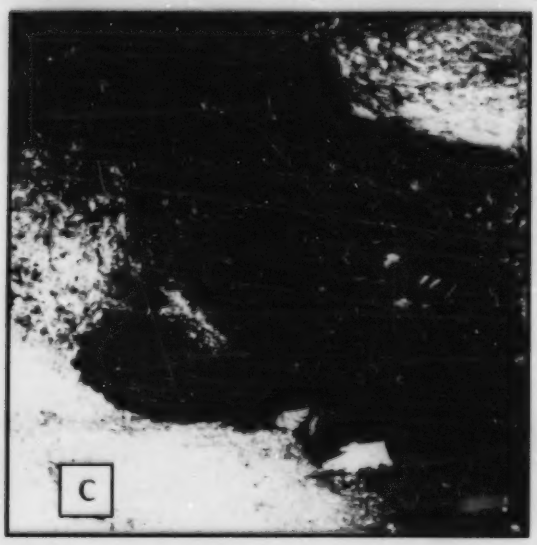
These collapse structures can vary in size from a few to several tens of meters in diameter. Sometimes they remain dry, in-filled with collapsed rock, glacial till and vegetation while in other instances they are filled by surface water run-off or by ground water flowing through the old underground workings.

With the exception of the former Sayre Mine and its adjacent small quarry near the northern limit of the "main" deposit, most underground mining activity was concentrated in its southern half. Former underground operations like the New Mine, the Ham, Smith, Seymour, Jones, D-51, West, North, New West and South mines were operated at one time or another in this part of deposit along with the Grey, Green, Bowman, Smith, Milton, Upper, and Tomkins quarries. Man-made sinkholes appear to be particularly well developed in parts of this area. This artificial process of sinkhole development is ongoing and presents itself as a concern in certain parts of the area considering the potential for locally unstable ground conditions.

The development of what appears to be an extensive subterranean drainage system is reflected in the number and distribution of surface water features throughout the area. Apart from water-filled sinkholes, the areas surface drainage network is dominated by Gray Brook, flowing west to east across the northern portion of the "main" sulphate deposit. The brook is fed by three main tributaries and associated secondary watercourses from the south. These are spaced roughly 750 m apart and originate from several springs linked to waters circulating through cracks and related fissures in the sulphate bedrock. In general the sulphate area is not affected by the retention of surface water in swamps and marshes.

General land use: Existing land use in the sulphate area and lands adjacent to it might best be described as recreational and light industrial (Figure 1). Locally,

Figure 5. A network of natural "wild caves" carved out the gypsum and anhydrite deposits near Hillsborough are a favorite with amateur spelunkers and tourist of all ages. Having been mapped extensively, these caves[1] are reported to comprise an interconnected network totaling 515 m, distinguishing them as the longest "gypsum" cave system in eastern Canada.



A. Gearing up to enter the White Cave system near Hillsborough, southeastern New Brunswick.

B. From the outside the cave entrance looks fairly obscure (Figure 4a), but once inside, a room 8x8x3 m high is revealed.

C. There are various vertical and sub-vertical cracks to explore throughout the cave system.

[1] For additional information on the Hillsborough and other cave systems in New Brunswick refer to *"The caves of southeastern New Brunswick"* by Arseneault et. al. 1997.

the unique landscape of the region features (karst, caves, vegetation etc.) are of interest to outdoor enthusiasts and tourists alike (Figure 5). The district supports an extensive trail network used primarily for hiking, mountain biking, orienteering, cross-country skiing and snowshoeing. A proposed provincial-hiking trail skirts around the western boundary of the deposit. A 60-hectare golf course development extends about a kilometer in a north-south direction along the eastern edge of the "main" deposit. A former quarried site incorporated into the course design, provides an excellent example of alternative land use in the wake of mining activities resulting in a rather unique and relaxing recreational experience (Figure 6).

Figure 6. Signature golf hole established in a former gypsum quarry near Hillsborough, N.B. View is looking from the putting green back towards the narrow tee-off area.

Half a kilometer from the eastern limit of the "main "deposit a 15 hectare wetland wildlife habitat site has been recently established.

Industrial activity in the area is limited to a few small timber-harvesting operations and more recently, a small limestone quarry has been established just east of the former King gypsum quarry ("east" deposit).

General Geology:

Although mentioned in several early publications, the most complete description of the gypsum and anhydrite resources in Hillsborough area date back to late 1800's (Bailey 1898). Most of these early accounts tended to focus directly on the development aspects of the gypsum resource, providing only limited background on the geology of the area. Among the first attempts to incorporate these deposits into a regional stratigraphic and structural synthesis was that undertaken by Wright (1922). Over several succeeding decades his initial conclusions would later be modified by several workers including: Norman (1932 ; 1941), Gussow (1953), Hamilton and Barnett (1970), Van De Poll (1973), McLeod (1980) and more recently by St. Peter (1989) and St. Peter and Johnson (1997). A summary tracing the development of stratigraphic nomenclature for this and adjacent map-areas is given in Table 1.

The Hillsborough area is underlain by Lower to Upper Carboniferous age clastic sedimentary rocks and related evaporites (Map Plate 2000-31, Appendix B). The oldest Carboniferous rocks are those belonging to the Horton Group, represented by red, fine- to coarse-grained alluvial to lacustrine clastic sedimentary rocks, including mudstone, sandstone, conglomerate in association with kerogenous shale, limestone, anhydrite, rock salt and glauberite. These rocks are unconformably succeeded by the fine- to

Table 1. Table of formations: Summary of stratigraphic nomenclature for Hillsborough and adjacent map areas.

Summary of stratigraphic nomenclature for the Hillsborough and adjacent area

Wright (1922)		Bell, (1927) & Norman (1932)		Norman, (1941) & Gussow, (1953)		Van de Poll, (1972)		McLeod, (1980)		McCutcheon, (1981)		St. Peter, (1997)	
Series	Zone	Series	Formation	Group & Formation		Group & Formation		Group & Formation		Group & Formation		Group & Formation	
Petitcodiac	2-3		Petitcodiac	Boss Point Fm.		Boss Point Fm.		Boss Point Fm.		Boss Point Fm.		Cumberland Gp.	Boss Point Fm.
	1		Demoiselle	Hopewell Gp. (Enrage Fm.)		Hopewell Gp.	Enrage Fm.						
							Shepody Fm.	Hopewell Gp.	Enrage Fm.	Hopewell Gp.	Enrage Fm.	Mabou Gp.	Hopewell Cape Fm
							Maringouin Fm.				Hopewell Gp. (undivided)		
		Windsor	Hillsborough Fm.	Windsor Gp. (subzones A& B)	Unit 10	Windsor Gp. (Subbzones A & B)				Windsor Gp.	Demoiselle Creek Beds	Windsor Gp.	Lime-Kiln Brook Fm.
					Unit 9				Unit 7a		Upperton Fm.		Upperton Fm.
					Unit 8						Gays River Fm	Macumber Fm.	Gays River Fm. / Macumber Fm.
				Hillsborough Fm.		Moncton Fm.	Hillsborough Member	Hillsborough Fm.		Moncton Gp.	Hillsborough Fm.		Hillsborough Fm.
	1			Weldon Fm.			Weldon Member		Rhyolite		Weldon Fm.	Horton Gp.	Weldon Fm.
Weldon	1-3	Horton	Weldon Fm.	Albert Fm.		Albert Fm.		Round Hill Fm.	Albert Fm.		Albert Fm.		Albert Fm.
Boyd	1-3		Boyd Fm.										
Albert	1-3		Gautreau Fm. / Albert Fm.										Memramcook Fm.

coarse-grained alluvial clastics and marine evaporites of the Windsor Group. More specifically the Windsor rocks of the area consist of a basal conglomerate succeeded by a sequence of limestone; a mudstone-siltstone-marlstone-breccia; sulphate (anhydrite and gypsum); and locally, a sulphate/dolomite breccia. Red, fine- to coarse-grained clastics of the Mabou Group overlie the Windsor strata. These rocks are unconformably succeeded by the area's youngest sequence of Carboniferous rocks, the Cumberland Group, comprised of medium- to coarse-grained arenitic sandstone, pebbly sandstone and quartzose conglomerate of the Boss Point Formation.

A small structural basin referred to as the "Gray Brook basin", a few kilometers west of Hillsborough, and a series of north-south and east-west trending faults are among the region's main structural features. These play a key role in the regional distribution of sulphate and related mineral deposits

Detailed Geology:

A detailed geology of the Hillsborough area is presented as Map Plate 2000-31 in Appendix B of this report.

The anhydrite and gypsum deposits in the Hillsborough area occupy a small structural basin, the Gray Brook basin. Situated about 1 km west of the village, the basin covers approximately 7.5 km^2 and contains a thick sequence of Windsor Group clastics and marine evaporites. Its eastern, western and northern boundary is generally comprised of the coarse-grained clastics of the Hillsborough Formation. The Hillsborough forms the base of the Windsor Group throughout New Brunswick and typically consists of red-brown conglomerate, coarse-grained sandstone with minor mudstone. These rocks are conformable with overlying limestone of the Macumber Formation. The Macumber, visible in several outcrops scattered around the basin's perimeter varies in color from reddish grey to olive grey to black. The limestone is typically a thinly laminated wackestone and packstone comprised of intraclastic carbonate of algal origin and other allochthonous material (*i.e.* pellets, oolites). Terms such as algal-laminated and flaggy are frequently used to describe these rocks (McLeod 1980), considered to range between 6 and 45 m thick (Wright 1922; Hamilton and Barnett 1970).

The Macumber limestone is generally overlain by a poorly indurated red calcareous mudstone (marlstone) containing minor fragments of limestone, shale and sandstone. These rocks are poorly exposed and bedding is very difficult to determine with any degree of confidence. An exposure on the west side of the basin dips to the east at an angle consistent with that of underlying the underlying Macumber strata, suggesting the limestone-clastic contact may be conformable. The extent and thickness of this marlstone-shale unit is apparently quite variable with estimates ranging from 4 m (McLeod 1980) to 60 m (Wright 1922). The nature of its contact with overlying sulphate deposits is not known with certainty. Hamilton and Barnett (1970) have proposed that the contact is conformable and gradational; however recent drilling in the southwestern part of the basin, where red mudstones are found interfingering and in direct contact

with sulphates would suggest a more complicated interpretation, one involving erosion (physical and chemical) at the sulphate-limestone interface and subsequent deposition of argillaceous and calcareous beds (*i.e.* a disconformity).

Sulphates deposits, consisting of gypsum and anhydrite overlie the limestone and clastic strata. The sulphate strata is commonly referred to as the Upperton Formation. The distribution of gypsum and anhydrite within the Gray Brook basin is quite variable. Anhydrite is generally dark blue-grey to light grey in color. It varies from massive to laminated (Figure 7) with minor nodular zones a few meters thick. Nodules sometimes referred to as "cannon balls" structures range from a few centimeters to a few meters in a diameter (Figure 8). These frequently occur in a gypsum matrix and are interpreted as marking the outer limits of a hydration "front", where anhydrite has been converted to gypsum by circulating formational waters. In places anhydrite is extensively fractured with fractures often filled with clear selenitic gypsum. Anhydrite is also found interfingering with gypsum at a few locations.

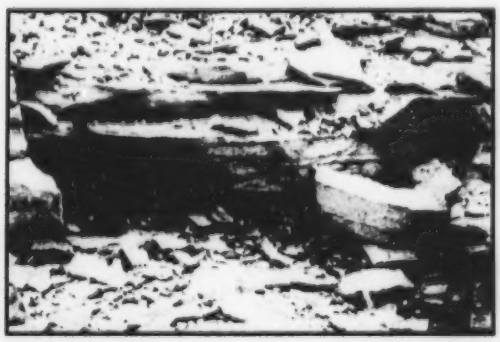


Figure 7. *Typical laminated anhydrite of the Upperton Formation, near Hillsborough, N.B.*

The Upperton gypsum resource in the Gray Brook basin is generally white to light grey in color. It is typically massive although bedded and nodular to disseminated varieties occur locally. Secondary gypsum occurs as veins crosscutting bedding and as randomly orientated selenite crystals distributed randomly throughout a gypsum matrix.

The thickness of the sulphate unit is estimated between 40 (Hamilton and Barnett 1970) and 150 m (Wright 1922). Gypsum thickness have been found to range from 18 to 30 m thick while a recent drilling program in the southwestern part of the basin has intersected up to 55 m of massive anhydrite (Whaley 1998).

Figure 8. Anhydrite "cannon-ball" structures comprised of anhydrite cores surrounded by an exfoliated gypsum crust. Typically found near major gypsum-anhydrite hydration fronts.

An unusual occurrence of dolomite / anhydrite breccia in a matrix of clear to white recrystallized gypsum with abundant selenite crystals and veins is found near an abandoned quarry (*i.e.*, the former King Quarry) at the southeastern limit of the basin. The stratigraphic significance of this lithotype is not known with certainty and only generalizations can be made in regard to its distribution. It may have resulted from the dissolution of an underlying rock salt unit (*i.e.* Cassidy Lake Formation) and the subsequent collapse of an overlying, regressive sulphate-dolomite sequence in this area. These rocks may be equivalent in part, to the Lime Kiln Brook Formation described by St. Peter and Johnson (1997) several kilometers to the south at Chemical Creek.

The upper part of the Mabou Group represented by red to maroon, fine-grained clastics of the Hopewell Cape Formation rests unconformably on and is in fault contact with Windsor Group strata along the southern margin of the Gray Brook basin. Buff to gray, fine- to coarse-grained sandstone, quartz-pebble sandstone and conglomerate of the Boss Point Formation of the Cumberland Group overlie Mabou clastic sedimentary rocks in this area as well.

The Gray Brook basin is an asymmetrical synclinal structure partitioned into several small fault blocks by a network of north-south trending normal faults offset by several northeast trending strike-slip faults. Some of these structures have received considerable attention over the last decade or so having been recognized as a potential source of potable water in the Hillsborough area.

It is suggested that the structural development (*i.e.* faulting) of the Hillsborough region has had a very significant impact on the selective formation and subsequent distribution of its gypsum and related anhydrite resources.

Deposit Type:

Calcium sulphate is typically the product of chemical precipitation from saturated brines resulting from evaporation at the air-water interface in marine basinal and related environmental settings. It is suggested that calcium sulphate in the Hillsborough area were originally deposited in the form of the mineral anhydrite in a deep-water, marine basin (Figure 9). Sulphate crystals generated at the air-water interface would gradually have settled on the sea floor forming primary bedded selenitic gypsum in shallow water and thick sequences of laminar anhydrite in deeper waters.

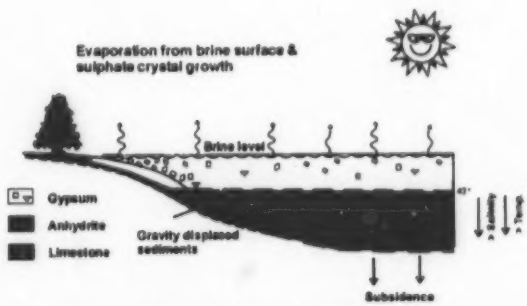


Figure 9. Typical depositional setting for primary calcium sulphate deposits.

Deeper water would have been characterized by elevated salinity and temperature - a setting where a primary gypsum precipitate would not be stable.

It appears that a considerable portion of the region's gypsum resources are the product of hydration of primary anhydrite (*i.e.*, absorption of water molecules into the anhydrite mineral structure). The regions structural development with respect to syn- and post-depositional faulting activity and associated fracture systems have had a direct impact on the effectiveness of the hydration process and the spatial relationship between gypsum and anhydrite (Figure 10). The deposits have also been altered by various episodes of recrystallization throughout their long history as well as some limited hydration from percolating surface waters.

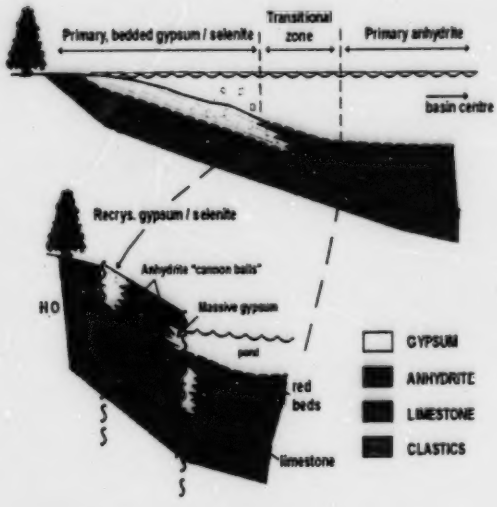


Figure 10. Formation of gypsum deposits in the Hillsborough area is directly linked to active hydration fronts developed along faults and related structures. Anhydrite 'cannon balls" generally mark the outer limit of individual hydration zones.

In summary the Hillsborough area sulphate deposits are represented by a blend of bedded primary gypsum and anhydrite, secondary gypsum (hydrated anhydrite) and limited recrystallized gypsum.

Exploration and Development History:

Prior to the 1950's, gypsum was a major contributor to New Brunswick's mining sector. The gypsum resources in the vicinity of Hillsborough were of particular importance, serving as the focal point of a thriving industry for well over a century.

The earliest indications of gypsum deposits in the Hillsborough area comes from a late 17th century document that refers to *"plaster at Beaubassin*[2]*, only thirty leagues from Port Royal"* (Webster 1934). Although it appears that some gypsum was exported from the area during the 1700's (Haldiman Papers 1767) it was not until the dawn of the nineteenth century that a fairly brisk gypsum trade developed with several American states situated along the Atlantic seaboard. It seems that a growing demand for soil amending materials, (*i.e.* fertilizer) in the form of land plaster for an expanding American agriculture industry had created a rather lucrative market for such material. Gypsum was dug from numerous hillside excavations and transported by horse and wagon to be loaded onto small American coastal vessels that frequented the region.

Despite several early attempts, this international trade proved very difficult for local officials of the British colonial government to regulate nor could its

[2] Beaubassin was an early French seigniory established in the region by the Acadians that included the territory now known as Albert County.

actual volume be accounted for. It was not until after the War of 1812, efforts were renewed to gain some control over this so called illicit "plaster economy". The profitable nature of the plaster trade soon became very apparent to local entrepreneurs. Much to the vexation of regional British custom officials the proceeds of plaster sales were often used to support an unofficial free trade zone. It seems that vast quantities of American and other worldly goods easily infiltrated the Bay of Fundy coastline and were commonly acquired duty-free by local consumers.

Earlier attempts to resolve this apparent illicit trade conundrum were often thwarted by the lack of regional cooperation. With a similar illicit gypsum trade in neighboring Nova Scotia a general consensus soon developed among officials that it was beyond the capability of the local colonial government in New Brunswick to legislate an effective "gypsum" trade policy beyond its own borders. Without the cooperation of Nova Scotia's legislature, any attempt to adopt and enforce legalistic measures seemed somewhat futile.

The situation was to change in 1816, when agreement between the New Brunswick and Nova Scotia legislatures resulted in regulations (Hannay 1902; McNutt 1963) requiring all vessels of British origin loading gypsum form the Bay of Fundy region to discharge their cargoes at American ports south of Boston. In theory this would have limited the gypsum trade to only larger vessels, forcing the smaller coastal ships engaged in the so called smuggling trade out of the gypsum business, leaving the high profits to the British businessmen. It was anticipated that thousands of tons of gypsum cargo would assist in the establishment of new British shipping enterprises in the region. At the same time, agricultural interests in the southern American states, which had become fairly dependent on land plaster would be forced to pay whatever British merchants deemed appropriate for the fertilizer product. It seems that only those merchants of Saint John, St. Andrews and Halifax that were able to supply larger ocean-going vessels would have been capable of engaging in this apparent lucrative trading venture. At the same time a significant portion of the contraband goods coming into the two provinces would now most likely be accounted for and appropriate duties collected. It was intended that the illicit trading activity in the Bay of Fundy region would in effect be by-passed and the local entrepreneur would have nothing to offer (*i.e.* gypsum) the Americans for their alleged duty-free goods.

In the short term all this trade posturing succeeded in accomplishing was rallying a spirit of reprisal from the American Congress, eager to uphold the mercantile interest of its New England shipping fleet. In 1817 an act restricting the importation of gypsum from the British provinces except in American vessels was implemented (McNutt 1963). The consequences of this action saw the illegal trading practice that the British legislation was designed to resolve, eventually revived. With both New Brunswick and Nova Scotia traders, spurred on by high prices being offered for gypsum, small shipments were often dispatched to the international border area of Eastport-Campobello Island where their cargoes were transferred to

American vessels. Such a situation eventually forced the two colonial legislatures to capitulate and repeal the controversial trade legislation in 1818.

Not to be discouraged the New Brunswick legislature continued its crusade to win control of the gypsum trade from the Albert and Westmorland County area. In 1820 an act, commonly referred to as the *Plaster Act* was passed, imposing a duty (*i.e.* "seven shillings and sixpence/ton") on all gypsum imported into Charlotte County (McNutt 1963). This strategy was an attempt to discourage the gypsum cargo transfer at Campobello Island and the adjacent American port of Eastport and others. Serious attempts were made this time to enforce the law of the land resulting in a few vessels, carrying what officials determined as smuggled gypsum cargo, actually being confiscated. These seizure incidents precipitated such an uproar featuring, armed and related acts of resistance that government officials were soon forced too back down.

Much to the delight and relief of the legislatures in New Brunswick and Nova Scotia, the plaster trade did not have a prolonged longevity. Fertilizer requirements of Atlantic-seaboard American agriculture were soon to be met by sources from the heartland to the west, namely substitute resources in Michigan and Ohio. The lucrative Bay of Fundy trading fraternity eventually diminished as British "plaster" merchants discovered that payment in fish, grindstones and hard currency was to become the foundation of future trade dealings with their American counterparts.
Despite competition, limited gypsum shipments continued from the Hillsborough area. Prior to 1847, Gesner (1847) reports the following exports:

Year	Commodity	Tons
1830	gypsum and limestone	1748
1836	gypsum	1015
1839	gypsum	7991
1845	gypsum	2034

The principal destination for these shipments was primarily the Lubec area, in the State of Maine, (adjacent the Canada-United States International Border, west of Campobello Island at the western end of Passamaquoddy Bay) where the Fowler Bros. (Fowler & Co.) had established a plaster mill. Sometime around 1850, the Fowler Bros. obtained property interests in the Hillsborough area and soon began to operate quarries there (*i.e.* the Fowler Quarry) for several years under the capable direction of Captain James Blight. Annual shipments apparently never exceeded much more than three thousand tons (Cole 1913).

In 1854, Calvin Tomkins, a New York cement and lime manufacturer, arrived in Hillsborough. With the import duty on manufactured plaster into the United States at a very low rate and considering the ample, high quality gypsum resource in the Hillsborough area, Mr. Tomkins was quick to realize a potential lucrative business opportunity for gypsum-based product, produced in Canada. Subsequently, he made arrangements to purchase some of the Fowler land holdings along with other properties in the area on which gypsum was known to occur. He was to establish several mines and quarries throughout the area and eventually constructed a large gypsum processing facility operating under the

name of the "Albert Manufacturing Company" (AMC). The company not only mined and processed gypsum at Hillsborough but also supplied crude gypsum rock to another Tomkins-owned plaster mill in Newark, New Jersey.

The prosperity of the newly established gypsum operation at Hillsborough was clearly dependent on the American market and the capricious nature of its trade policy. Limited domestic demand high freight rates, competition from Nova Scotia and the low rate of duty imposed on manufactured plaster imports from the United States, all contributed to make the Canadian market an uneconomic alternative for manufactured plaster and related materials from Hillsborough.

For almost twenty years the Hillsborough gypsum industry continued to expand however, AMC suffered a devastating setback in 1872 when its entire mill was destroyed by fire. Mining and shipments of crude stone to its US-based equivalent continued while a new mill was hastily rebuilt, opening a year later in 1873. One of the factors that may have assisted the mills speedy reconstruction was the anticipation and launching of the long-awaited extension of the Inter-Colonial Railway network into the Hillsborough area in 1876. With the railway came a general lowering of freight rates to the rest of Canada. This development, along with increases to an import duty imposed earlier on U.S. plaster imports (Bailey 1898) and the excellent quality and reputation of Hillsborough plaster products in an significant increase in Canadian plaster sales. In fact over the next couple of decades sales were to increase fourfold, from about 8 000 barrels[3] in 1877 to 38 000 barrels in 1897 (Ells 1907).

In the early 1880's a restrictive duty of 29% was imposed on ground gypsum imported into the United States. Although this was to limit shipments of Canadian processed material the movements of crude stone continued upward unabated (Hamilton 1883), increasing over eleven times during the 1880 and 90's, from 5 000 to 59 334 tons. It was only after the infamous *Wilson Bill,* that the import tariff on manufactured plaster into the U.S. was sufficiently modified to allow average annual shipments of about 20 000 barrels (Bailey 1898). Unfortunately this auspicious state of affairs surrounding U.S. imports was compromised in the late 1890's by yet another restrictive tariff imposed under what was known as the *Dingley Bill*. The Dingley Bill was apparently championed by plaster producers in the western states as a means of gaining access to the lucrative plaster market along the Atlantic seaboard. Originally a duty of $2 per ton (Bailey 1898) was requested however it is not clear if this was to be applied to imports of crude gypsum or manufactured plaster or both. Either way the legislation was not particularly welcomed from those manufacturers already established on the America's East Coast. The east-coast manufacturers concerns were supported from the owners of U.S. coastal vessels. These vessels were engaged in discharging various bulk cargoes like coal into New England ports. After unloading they would then proceed empty a short distance to the Bay of Fundy where they would take on a load gypsum as back-haul freight to various

[3] A barrel was roughly equivalent to 300 pounds

U.S. coal-loading terminals along the Atlantic coastline. The gypsum cargo was of considerable importance in lessening the return costs to coal ports as well as minimizing freight rates for coal and related products throughout the region. Other American lobby groups representing agricultural interests were also opposed to such action having become accustomed to a steady supply of Canadian gypsum as a fertilizer supplement. In response to these protests, the proposed rate of duty was lowered to $0.50 per ton for crude gypsum while the rate for manufactured plaster was set at $2.25 per ton. Nonetheless, such action made it extremely difficult for a Canadian plaster manufacturer to compete with their U.S. counterparts. Despite this apparent setback the superior quality and reputation of Hillsborough crude gypsum and its line of high-quality manufactured plaster products (i.e. fine casting and dental applications) enabled it to retain a respectable share of the American market.

The first decade of the twentieth century saw continued production of crude gypsum from several AMC quarries and underground mines in the area. Figures reported in 1905 indicate 137 551 tons of crude rock was mined with 15 000 tons for calcining and the balance 122,551 being shipped as "crude" (Ells 1907) AMC's Hillsborough operation employed between 300 and 350 persons (Figure 11).

By the end of the decade (1908-1909) the American gypsum industry became embroiled in an internal difference of opinion over gypsum import tariffs. Midwestern state gypsum producers and

Figure 11. Albert Manufacturing Company's mill, Hillsborough, N.B., 1911 (source: Jennison 1911, p. 142)

manufacturers squared off once again with those producers on the Atlantic seaboard, heavily dependent on crude rock imports. In 1908, U.S.-Atlantic-coast gypsum industry using imported rock from New Brunswick and Nova Scotia consisted of nine production facilities spread out from Maine to Pennsylvania (Jennison 1911). Given their obvious dependence on this material, these enterprises were particularly anxious to have the $.50/ton import duty import on crude rock imposed earlier, reviewed and subsequently reduced. The growing mid-western gypsum industry lead by the U.S. Gypsum Company (USGC), however, were not like-minded, lobbying government officials for an actual tariff increase on crude rock and related manufactured products. This USGC-lead lobby group claimed their rock and manufactured product (s) could not reach eastern markets and effectively compete with similar imported material. They also complained that imports were in fact having a negative impact in their own market area. The economic banter went back and forth until a government

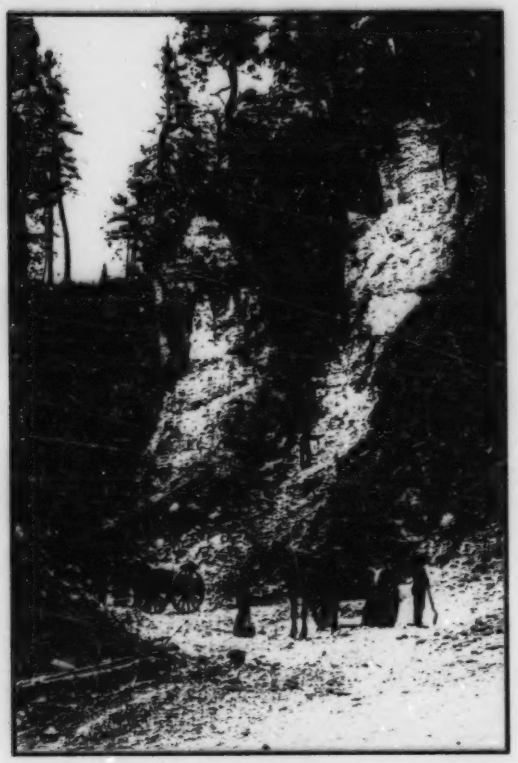


Figure 12a. Typical gypsum quarry near Hillsborough, New Brunswick, ca. 1914. Horse-drawn "Scotch Carts" in the foreground were commonly used to transport ore to nearest "narrow-gage" rail siding (see Figure 17b) for dispatch to mill (source: Crown Land Report, 1914, p. xvi)

Figure 12b. Opening up a gypsum quarry near Hillsborough, N.B. , ca. 1917 (source: Crown Land Report, 1917, p. 32)

Figure 12c. "Bringing out gypsum from [an] underground quarry," Hillsborough , N.B. (source Crown Land Report 1917, p.32)

committee finally ruled a general reduction in gypsum tariffs, much to the happiness of eastern producers and the dismay of the opposing western lobbyists. With the introduction of the appropriately named *Payne Bill (*from a western perspective of course), the $.50/ton duty on crude rock was subsequently reduced to $.30 and the duty on manufactured gypsum products went from $2.25/ton down to $1.75 (Jennison 1911). The ruling attempted to address significant inequalities in production costs between eastern and western producers with western costs (at the mill) $2.50 to 4.00/ ton cheaper. It also revealed a government objective not to completely prohibit the importation of gypsum but actually encouraged it for revenue purposes.

Although lower duties resulted in increased Canadian shipments of crude gypsum rock to east-coast U.S. mills, shipments of finished plaster products remained at a relative low level.

In 1910, records indicate AMC extracted 93 499 tons of gypsum from four properties: three near Hillsborough and one nearby at Albert Mines areas. Between 55 000 and 60 000 tons of crude rock was exported to destinations in Canada and the United States with minor shipments to Australia. The balance was utilized by the local Hillsborough mill for the production of Plaster of Paris, hardwall plaster, and land plaster.

Plaster production at Hillsborough in 1910, saw 110 000 barrels exported to Canada while only 18 000 were shipped state-side (Annual Report: Crown Land Department 1910; p. xxii). In March of 1911 tragedy struck the Hillsborough operation. Once again, its mill was completely destroyed by fire. The mill had apparently been closed for several weeks undergoing extensive and costly repairs in anticipation of a busy production season. Coincidentally the mill was to reopen on the very day of the fire. Despite the calamity at the mill site, mining operations continued along with the development of new properties (*i.e.* Cape Maringouin) in other parts of the region. However, the loss of the mill coupled with American protective tariffs saw overall gypsum production at Hillsborough sink to 65 000 tons.

After considerable deliberation, the mill manager at the time, the Honorable C. J. Osman, was able to convince the company's New York-based directors to rebuild the facility despite concern over severe competition and a product *"disposed of at prices which were not remunerative"* (Bishop 1925). Realizing the importance of the industry to their community, Hillsborough's Municipal Council granted the company an exemption from local taxation for a period of time, an incentive that company officials *"greatly appreciated"* (Bishop 1925). By May, 1911, work began at clearing the devastation at the former plant site. The new mill opening a year later in 1912 (Figure 13).

Throughout this period the company's mining operations increased production to 70 000 tons. With the new and improved processing facility in place company workers were able to turn out plaster at the rate of 800 barrels per day, resulting in a total output of over 130 000 barrels in its first year of operation Annual production at the companies mines continued at a steady pace, ranging from 70 000 to 90 000 tons up until the beginning of the World War I in Hillsborough's production with the balance used locally to produce plaster (approximately 120 000 barrels annually) at the local mill. The entire

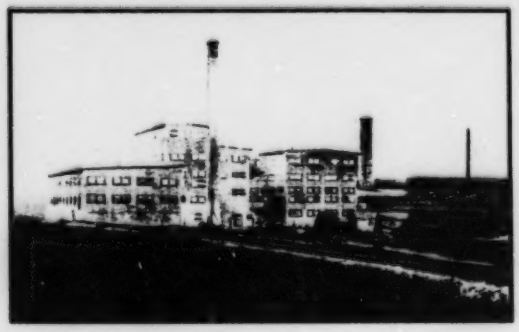


Figure 13. Mill and buildings of the Albert Manufacturing Company, Hillsborough, N.B., 1912 (source: Cole 1913, p. 51)

operation had provided employment for near 300 persons.

With the war came various restrictions on the building and related construction industry throughout North America, on which the gypsum business was very dependent. This situation had serious production consequences for the Hillsborough industry. Even though there remained a good demand for gypsum in the U.S., it was virtually impossible to arrange shipment there by water. Production of crude rock from the Hillsborough mines and quarries was subsequently reduced to 41 360 tons by 1916 with less than 7 000 tons exported (15% of total production in 1916 compared to 70% in 1915). Most of the mined-rock was locally processed into a calcined- and hardwall-plaster product and marketed by rail in other parts Canada. Although the situation in the building industry moderately improved by the end of the year, transportation still remained a major marketing bottleneck. High freight rates made water shipment expensive and uneconomic at current market prices. This situation coupled with the inability of rail service in the region to supply enough cars to move sufficient volumes of product, eventually forced the closure of the Hillsborough mill for a short period of time until high product inventories could be satisfactorily reduced to a manageable level. With the annual closing of the Port of Montreal to navigation during the winter months and the subsequent increase in rail traffic to the Maritime ports of Saint John and Halifax, it was hoped that enough rail cars that would normally return west empty would be made available to the gypsum industry and help resolve the transportation dilemma.

By 1918, total manufactured gypsum output at Hillsborough had been reduced to 25 825 tons with only 1600 tons of crude rock sent to the U.S. With the prolonged downturn in the North American building industry it appeared that gypsum production in 1918 would have established an all time low for AMC had it not been for the reconstruction of homes, buildings and related infrastructure in the aftermath of the devastating Halifax explosion[4]. At around the same time the take-over of the existing Albert Railway network by the Canadian National Railway resulted

[4] On December 6, 1917, a collision in Halifax harbor between two ships, one with full cargo explosives, precipitated one of the world's greatest man-made explosions. Hundreds of hectares covering much of the city's north end was leveled directly by the blast or severely damaged by a raging firestorm as wooden structures collapsed inward on stoves and furnaces in its aftermath. Between 1600 and 2000 persons are reported to have perished in the disaster with several thousand injured. Over 1600 buildings were completely destroyed while 12 000 were damaged, leaving 6000 persons homeless and an additional 20 000 with little to no shelter (Kernaghan 1995). Total damage was estimated at $35 million, roughly equivalent to 9 billion in current dollars.

Relief began immediately and eventually a vast assortment of building materials and hundreds skilled laborers were arriving daily to rebuild the devastated part of the city. Three thousand homes were repaired in the first seven weeks following the blast with over 325 new homes constructed a few months later (Halifax Regional Municipality 1999) . Such a construction project provided an important market to the struggling plaster mill and related gypsum operations at Hillsborough.

in improvements in the availability of rail cars in the region. Despite several production setbacks throughout the war years AMC continued to be fairly active in prospecting and related mine development work in advance of establishing future hillside quarries and underground mining operations.

By the end of the war (1919) a modest increase in total gypsum output at 28 900 tons was realized with most material consumed locally for plaster manufacture. Modest shipments to the U.S. soon resumed.

With the post-war demand for plaster products appearing to show signs of recovery throughout eastern North America the Hillsborough industry like many others manufacturing industries throughout the region soon found itself faced with a labor shortage. The war had taken its toll on the availability of a trained labor-force. Even though the company struggled to maintain close to full working levels at both its mining and mill operations, the inexperience of newly hired mine workers saw the daily output of plaster product exceed the feed of gypsum ore from various mining operations. This production bottleneck soon created a backlog of orders. It seems that the shortages of mill feed material was primarily due the nature of the "run of mine" gypsum sent to the mill for processing. The problem apparently had nothing to do quality of the rock itself, but was related to its free water content. Mine workers were able keep pace with rock demands from the mill but the existing workforce was not sufficient to establish adequate stockpiles of air-dried gypsum which apparently could be manufactured at a much higher production rate than moisture-laden material coming directly from the mines.

The 1920's saw another company, the Hillsborough Plaster, Quarrying and Manufacturing Company Ltd.[5] [HPQM (a subsidiary of the J.B. King Company of New York)], enter the gypsum business in the Hillsborough area. This company managed by James Blight, had already established gypsum mining interests (Mining Leases # 1&2) in the Demoiselle Creek area, 7 to 10 km south of Hillsborough, near the community of Albert Mines. In December 1920, records indicate that Hillsborough Plaster was issued a mining lease (Lease # 174) for property in close proximity to Edgetts Landing a few kilometers south of the AMC plaster mill. Several small interconnected excavations collectively referred to as the Edgetts Landing Quarry [6] were eventually opened with 7000 tons of *"very fine white rock"* extracted by heavy machinery (*i.e.* steam shovels), crushed on site and subsequently shipped to American plaster mills. Hillsborough Plaster eventually expanded its development activities on this and other land holdings in the area, making use of a government-owned diamond drill to further test the extent of gypsum deposits in the vicinity of its quarry sites and a prospect near Hopewell Cape[7], about 10 km south of Hillsborough.

In the meantime total annual gypsum output from the Albert Manufacturing Company continued its upward post-war recovery, with production reported at around 30 000 tons in 1920. Most production came from four properties west of Hillsborough with limited tonnage from another small operation in

[5] sometimes referred to as the "Hillsborough Plaster Company" (Bishop 1925; p.22)
[6] sometimes referred to as the "Hillsborough Plaster Quarry" (Bishop 1925; p. 22) or more commonly, the "King Quarries")
[7] gypsum extent and quality not encouraging (Annual Report of Crown Land Department 1920; p. 97)

the Demoiselle-Albert Mines area to the south. Mining and related crude rock shipments from yet another satellite operation on the east coast of Shepody Bay, at Cape Maringoiun (Lease # 50) were suspended indefinitely due to the destruction of a mill in New Haven Connecticut, its main captive market.

The availability of an adequate work force that plagued the operation the previous year showed signs of improvement and by the end of the year (1920) it was reported that *" there is more available labor, than can be employed"* (Annual Report: Crown Land Department 1920; p. 96)

The period from 1921 to 1923 saw the gypsum industry at Hillsborough continue its steady upward trend. Both AMC and HPQM reported increases in total crude rock output with more rock being shipped to the U.S. It was reported that some AMC mill product was finding its way *"to the ends of the earth"* (Annual Report: Crown Land Department 1922; p. 54), with large cargoes sent to New Zealand and smaller shipments to Australia, Japan, South Africa and Zanzibar.

In the spring of 1922, Albert Manufacturing Company's longtime manager and president, the Honourable C.J. Osman passed away. Mr. Osman was succeeded by a Mr. F. M. Thompson, who supervised yet another milestone in the company's seventy year history - the prospect of adding a "plaster board" line to its long list of products. Mr. Thompson's inaugural year as manager saw the company's total output of crude rock increase to 66 044 tons extracted from six quarries. Another excavation, characterized by a 40-foot cliff face, referred to as the Whitehead Quarry was opened near the western perimeter of the "main" gypsum deposit [see inset map A; Map Plate 2000-31 (Appendix B)]. The company employed about 250 men at this time and had added two additional retorts, increasing the mill's calcining capacity by almost 50%.

Meanwhile, Hillsborough Plaster continued its rock shipments to New England from its Edgetts Landing (38 800 tons) and Demoiselle (8 000 tons) locations, employing about a hundred men between May and November. The operation's parent company, the J.B. King Company, amalgamated with the United States Gypsum Company which initially had proposed to expand the Hillsborough operation's annual output upwards to 100 000 tons.

Hillsborough Plaster's two quarries continued to supply gypsum up until 1925. In 1926, the USGC conveyed control of its Hillsborough properties to its Canadian affiliate, the Canadian Gypsum Company, established in 1907. With company priorities firmly targeted on several properties in Nova Scotia very limited production and subsequent development work was undertaken at the former Hillsborough Plaster quarry sites. By 1927 AMC was the only company quarrying gypsum in New Brunswick. The Company's position related to the export of crude rock began to change around this time with attempts made to process more rock at Hillsborough. Even so, trade limiting tariffs and other restrictions on finished plaster products imported into the U.S. combined with the limited size of the Canadian market continued to make crude rock shipments an important part of company's business plan, accounting for roughly 40% of its total output. To improve its market competitiveness in this area new storage and handling facilities consisting of two 1500 ton capacity silos (Figure 14) were

constructed and integrated into the company's ship loading capabilities at its Petitcodiac River loading facility.

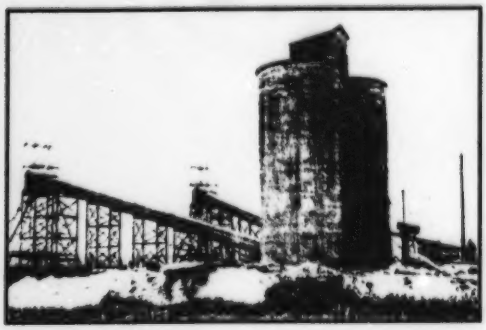


Figure 14. Storage bins [silos], loading belts and shipping pier, of the Albert Manufacturing Company, Hillsborough, N.B., 1930 (source: Cole 1930, p. 29). The remnants of these structures are prominent landscape features of the shoreline along the Petitcodiac River less than a kilometer east of Hillsborough.

These structures proved to be a highly efficient means of storing air-dried rock. They could be filled within two and half-hours and could load vessels in three to four hours allowing for very quick dispatch given the limitation placed on loading due to the widely fluctuating tides in the river channel and the adjacent Bay of Fundy.

Improvements were also made to the mill, increasing plaster production capacity. Six retorts each with a capacity of 10 tons could deliver 8 charges over a 24-hour period resulting in a total daily plaster output of 500 tons. Improvements were also achieved in the packaging of specialty plaster products such as dental plaster (*i.e.* 10, 25 and 100-pound tins vs. 150 and 300-pound packages). While Canada continued to remain the principal market for plaster, shipped by rail over the Salisbury-Albert Branch of the CNR, limited shipments were also being made to New England, Australia, New Zealand, South Africa, the West Indies and Japan. Attempts were also underway to establish market connections with the United Kingdom.

In 1930 and contrary to all the improvements appiied to Albert Manufacturing operations, company officials announced the sale of the company would be sold. All its assets and holdings including quarries, mines, mining leases and processing facility and related infrastructure were to be transferred to the Canadian Gypsum Company (CGC), a subsidiary of the USGC (Figure 15).

ALBERT MANUFFACTURING CO. PROPERTY CHANGES HANDS

Canadian Gypsum Company Secures Control of Important Albert County Industry in Financial Transaction—Hope to Expand Operations

IS HURLED FROM CAR AT 45 MILES AN HOUR

PLANE THEFT CASE OVER TO MONDAY NEXT

Counsel for Defense to Consider Whether He Will Call Witnesses

THIRTY-FIVE OF ANGLICAN CLE DIOCESE IN

Conducted by V. Dean Arthur Ca Montreal, at R

PROVINCIAL-HI VISITS PRE

Figure 15. "Albert Manufacturing Co. property changes hands" (source: The Moncton Transcript, Sept. 9, 1930)

Despite a production history spanning seventy-six years, the motive(s) behind the AMC- sale remain unclear and speculative. Perhaps fluctuation s in U.S. trade policy reflected in high tariffs on U.S. imports of refined and processed gypsum and the anticipation of additional protectionist measures

resulting in higher import duties on crude rock shipments, a source of constant anxiety among the company officials, had finally taken its toll. The accumulated debt related to the recent improvements to the Hillsborough operations coupled with the growing trend toward the introduction of alternative gypsum products like wallboard may have been among contributing factors. More importantly, economic uncertainties precipitated by the onset of the Great Depression (Hayes 1929) in the late 1920's, was probably at the center of the acquisition.

The CGC acquisition actually added a measure of stability to the Hillsborough gypsum industry. Apart from being directly connected to a major continental producer, CGC introduced a wallboard manufacturing line to the Hillsborough plant within a year (1931) of its acquisition. This expansion, provided 20 to 25 new jobs as well as spin-off during the construction phase, and was particularly important in minimizing the social impact of the economic calamity facing most of North America. However, the company could not totally escape the lethargic economic situation facing the general construction industry and was soon forced to decrease its total gypsum output from 88 735 tons in 1929 to 35 000 tons by 1935. A job-sharing initiative was implemented as a means of retaining experienced workers until business conditions improved. With such a measure, employment levels were to fluctuate between 100 and 140 during this period.

Several new products (*i.e.* roofing tiles, hollow form partitions etc.) were developed during this period. There was also more emphasis placed on processing raw gypsum into various products at the Hillsborough plant rather than exporting crude rock elsewhere for processing.

By 1936 the economy and the building industry in North America was showing signs of improvement. A good demand for wallboard was developing in Great Britain. The later part of the 1930's saw a gradual increase in total gypsum output from Hillsborough. Raw gypsum production eventually reached 47 000 tons by 1938, with slightly over half shipped to American mills and the balance processed into: wall and gauging plaster, rock lath, wallboard (sheetrock), gypsum partition tile and roof tile (pyrobar), dental plaster, molding and pottery plaster and other products.

Despite the onset of World War II in Europe in 1939, the gypsum industry at Hillsborough continued to prosper. Even though the war had seriously impacted overseas trade, there remained a very strong domestic demand. New wallboard products (gyplap) and an improved "joint system" began to be used extensively in the construction of military buildings (*i.e.* troop-camps and related structures).

Throughout most of the 1930's CGC had extracted most of its gypsum from underground workings of the Seymour-Jones and the Smith mines near the southwestern limit of the "main" deposit in the Gray Brook basin (see map inset A, Appendix B)]. After supplying many thousands of tons of gypsum ore, these operations were showing signs of depletion in the early 1940's. This situation prompted an extensive diamond drill program involving 37, sixty-foot holes to the east and southeast and the development of a new underground operation, the New Mine, a short distance to the north. Between 1942 and 1945 the New Mine became the main source of gypsum for CGC operations

complemented by a small quarry opened in 1943 in the northern part of the basin adjacent the former Sayre Mine, which had operated for a short time during the 1920's. Both sites were linked directly by a narrow gauge rail line to the Hillsborough mill facility (Figure 16a and 16b).

Figure 16a. Pit-run, quarried gypsum was generally hammered down to smaller-sized material for easier handling. This material was loaded onto a single-horse, two-wheeled "Scotch Cart" (source: Annual Report, Crown Land Department 1914, p. xvi),

The end of the war and the massive rebuilding program that followed saw gypsum output from CGC's two operating quarries and one underground mine climb to 106 616 tons by 1949 with all production reportedly consumed by the local manufacturing plant. In the early 1950's the company once again embarked on an extensive assessment of gypsum reserves undertaking a detailed exploration drilling program over their Hillsborough properties as well as those at Demoiselle Creek, near Albert Mines, a few kilometers south.

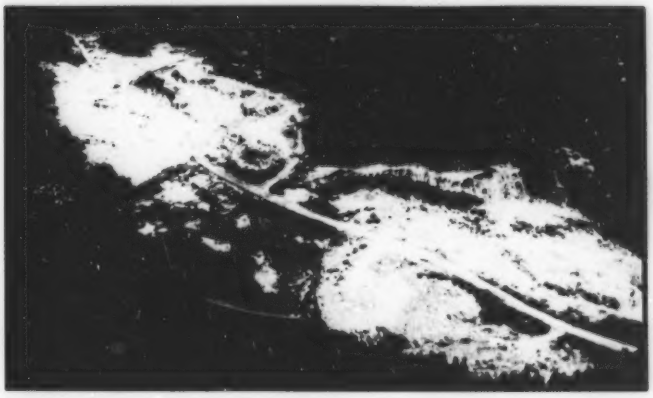
Over the next thirty years CGC continued to operate, eventually consolidating mining activities to one

Figure 16b. Gypsum was hauled to the nearest "narrow gauge" railway siding where it was dumped directly into three and half ton cars. Small, specially designed locomotive(s) locally referred to as the "Tadd-" and "Connie-" trains shunted up to 30 cars of ore at a time to the mill, 6 to 8 km away. Each train had the capability of delivering 600 to 700 tons of ore daily. (source: Thomas, 1930, p. 93)

quarry a few kilometers south of their Hillsborough processing facility (Figure 17). For the most part annual gypsum production continued in the 70 000 to 90 000 ton range up until about the late 1970's when production dipped below 50 000 tons.

By 1980, fifty years of continuous wallboard and related manufacture of gypsum related products had taken its toll on the Hillsborough plant. The plant, at one time among the most progressive and "state of the art" gypsum product facilities in Canada had become very much outdated and inefficient compared with modern industry standards. In addition, a downturn in the construction industry had made the gypsum wallboard market highly competitive and price sensitive. Considering the antiquated condition of

The King Quarry... the last gypsum quarry to operate in the Hillsborough, N.B. area (circa. 1978).

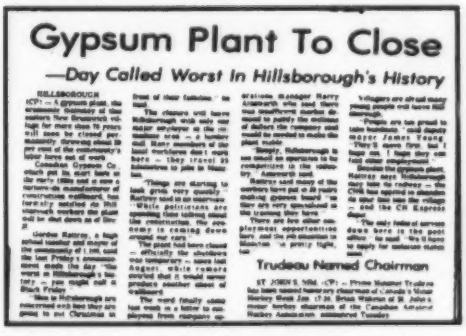


The former wallboard and gypsum processing facility of the Canadian Gypsum Company at Hillsborough, N.B. (1978). This facility was closed in 1980 after operating for more than a century.

Figure 17. Operations of the Canadian Gypsum Company, Hillsborough, N.B. (circa.1978).

the facility and the limited regional market for its main gypsum product, wallboard, CGC decided to permanently close the Hillsborough operation at the end of 1980 (Figure 18).

CGC's mining rights to the gypsum resources of the area were eventually relinquished and transferred back to the Province of New Brunswick. Over the last twenty years or so interest in the remaining gypsum resources at Hillsborough has been limited. In 1986-87, a mineral claim block consisting of 34 claims (550 hectares) was established in the area on behalf of officials at Eastern Gypsum Inc. At that time



Gypsum Plant To Close

—Day Called Worst In Hillsborough's History

Trudeau Named Chairman

Figure 18. After a presence for over one and thirty years, the Hillsborough gypsum industry is terminated, following Canadian Gypsum Company announcement to permanently suspend operations at the end of 1980 (source: The Daily Gleaner, December, 1980).

Eastern was in the process of establishing a wallboard manufacturing plant in southwestern New Brunswick and was interested in locating an indigenous source of gypsum.

A compilation of geotechnical data provided by the former operators, the CGC, proved inconclusive in detailing the location and quality of remaining gypsum reserves on the property. This situation precipitated a general review consisting of reconnaissance mapping of the property along with sample collecting and preliminary evaluation of several former quarry sites (Brown and Whaley 1986).

Thirty-seven samples were eventually collected with over eighteen yielding greater than 80% gypsum (Appendix A). It was generally concluded that the central and northern part of the "main" deposit [*i.e.* north of the former "Ham and Jones Mines" (see map inset A, Map Plate 2000-1, Appendix B)] and an area formerly quarried to the southeast [*i.e.* King Quarry area (see map inset A, Map Plate 2000-1, Appendix B)] might contain additional gypsum; however drilling would be required to quantify and qualify the material. A limited follow-up drilling program was undertaken in 1987 to 88 to test the southern limit of gypsum remaining in the former "King Quarry". This work consisted of three holes, totaling 42.9 m, spread-out in an east-west direction just south of the quarry's working face and adjacent an east-west trending fault. All failed to intersect gypsum and were terminated at depths ranging from 12.2 to 15.5 m. Exposures of the formerly worked quarry face were selectively sampled. It was suggested that approximately 400 000 tonnes of 88% gypsum might be left at the former quarry site with the potential for additional resources below the quarry floor (Whaley 1988).
Extensive drilling was recommended for several areas prior to a decision to abandon some or all of the claims within the block

In 1990 Eastern's Hillsborough-holdings were reduced to 17 claims. Although parts of the claim block had been explored earlier by CGC (*i.e.* with many shallow drill holes) no detailed records were available for review. Be that as it may a few potential gypsum sites were identified to the east and south of the former Ham Mine (see map inset A, Map Plate 2000-31, Appendix B). Eastern chose one area, referred to as the Britton Farm property as the target for three drill holes. Overburden thickness in the drilled area ranged from 19.8 to 20.9 m with 1.1 and 12.9 m of gypsum intersected averaging 75.97 and 82.70 % $CaSO_4 \cdot 2H_20$, respectively (Whaley 1990).

Following discussions with former CGC employees who had worked the King Quarry, the potential for additional reserves below the quarry floor appeared remote.

Eastern's Hillsborough claims eventually expired with no additional work reported. Parts of the property were re-staked (9 claims) in 1994 and 1995[8] for K.D. A. Whaley, interested in exploring the possibility of recovering gypsum from some of the abandoned quarries and former underground mines. These claims were regrouped into one claim block (#2567) in 1996. Mr.

[8] These claims were regrouped into one claim block in 1996

Whaley commenced a comprehensive program of geologic mapping, trenching, and geophysical surveying to locate favorable development sites. It was hoped that crown support pillars left behind following the abandonment of former room and pillar mines could be located and would be large enough to support a proposed recovery operation. The area chosen to investigate was in the vicinity of the South Mine (see map inset A, Map Plate 2000-31, Appendix B). Magnetometer and VLF geophysical methods were to prove unsuccessful in locating old mine workings. Trenching in a few areas did however, expose several pillar structures. Unfortunately these were much smaller than originally thought and were often contaminated with overlying till. It became evident during the course of the investigation that some pillars had already been removed earlier although there is no record of this activity. The two former quarry sites in the study area were considered to have limited potential. Part of the old Tompkins Quarry was found to contain about 15 000 tonnes of high-grade, "terra alba" material. Further to the west 20 000 to 30 000 tonnes of lower grade gypsum considered suitable for agricultural use (*i.e.* land plaster) was identified (Whaley 1995).

In 1998, Whaley's claim block (#2567) was renewed and 24 more claims were recorded as claim block #3443 covering a combined area of 528 hectares. In addition to remaining gypsum resources in the area Whaley's company, Mactaquac Mining Ltd., became interested in evaluating and confirming anhydrite resources often found in association with the area's gypsum deposits. Thirteen diamond drill holes totaling almost 674 m were put down near the western end of the former Tomkins Quarry. The program was successful in identifying a drill-indicated resource estimated at 18 million tonnes of at least 98% anhydrite (Whaley 1998). As of the spring of 2000 no additional work has been reported on the Hillsborough gypsum / anhydrite properties.

Exploration Model:

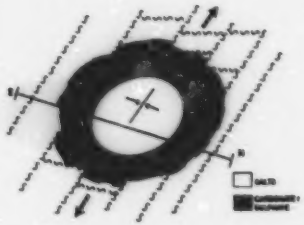
The structural and geologic evolution of the Gray Brook basin and adjacent area may be related to development of syn-depositional steep-sided fault scarps around the periphery of a larger subsiding basin (Figure 19).

Deposits of carbonate and sulphate accumulating on the basin margins would have been fairly prominent physical features of this faulted terrain forming a series of ridges, steep cliffs and /or escarpments.

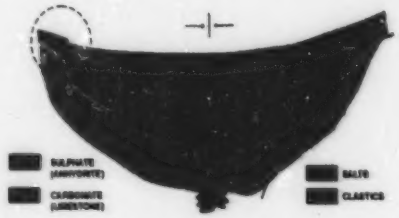
The termination of evaporite deposition in the Hillsborough region is marked by the gradual infilling of these basinal structure(s) by continental clastics of the Mabou Group (Figure 19). This period of sedimentation was characterized by a steady flow of sediment-laden fresh water probably from a positive source area to the south or southeast. This water flowed into the basin area, forming a series of scattered ponds or small lakes juxtaposed anhydrite fault scarps at various locations. These bodies of water would have not only have supplied continuous medium for hydration of the anhydrite to gypsum but also would have exerted considerable pressure against the "anhydrite walls" creating fracture systems further contributing to the

Figure 19. As one worker a long time ago so eloquently stated *"the [New Brunswick] gypsum deposits...are exceedingly varied in character, and in their mode of occurrence present many features of geologic interest."* (Bailey 1898). The following is offered as an alternative explanation for what appears to be a rather complex "diagenetic" origin of New Brunswick's gypsum deposits.

During the late Visean, several northeast trending oblique rift-like basins in southern New Brunswick served as important depocentres for thick evaporite deposits

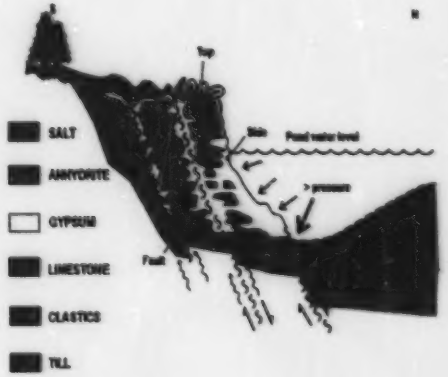


Around the periphery of these basins, syndepositional steep-sided fault scraps developed parallel and also at right angles to the axis of the basin (*i.e.* collapse structures) responding to more or less continual basinal subsidence. Deposits of carbonate and calcium sulphate accumulating on the basin margins and floor would have been fairly prominent physical features of this faulted terrain, forming a series of ridges, steep cliffs or escarpments. Considering the arid climatic conditions of the late Viséan, surface hydration of any exposed anhydrite (anhydrous calcium sulphate) was probably minimal.



The termination of evaporite deposition in the basin was marked by it's gradual in-filling with continental clastics. This period of sedimentation was characterized by a steady inflow of sediment-laden fresh water. This water would have flowed into the basin probably forming a series of scattered ponds or small lakes juxtaposed the anhydrite fault scarps at various locations. These bodies of water would have not only supplied continuous contact water for anhydrite hydration but also would have exerted considerable pressure against the "anhydrite walls" contributing further to the extent of hydration within the anhydrite body.

Water penetrating the stratified anhydrite was probably selective with hydration advancing along bedding planes and major contacts as well as upward along pre-existing faults and adjacent fracture systems. The location of these ponds and periodic fluctuations in water levels within them may also have influenced the degree of local hydration.



Following this relatively early hydration event(s), various structural adjustments in the area probably resulted in the further alteration of the sulphate deposits. The affect would have been to shatter sulphate beds adjacent to faulted areas, making way for additional hydration of anhydrite and recystallization of existing gypsum (i.e. the formation of selenite crystals).

In the late 1950's it was suggested that New Brunswick's gypsum deposits were hydrated from anhydrite during the post Pleistocene time (Sund 1960). However, contrary to this explanation it is suggested that most of the hydration process was probably underway and mostly completed much earlier. In fact some of these deposits have (locally) undergone multiple hydration, recrystallization and possibly even some dehydration throughout their long history.

penetration of the hydration front within the anhydrite mass. The initial penetration of water into the anhydrite was probably selective advancing along bedding planes and major contacts (*i.e.* limestone-sulphate) as well as upward along secondary expanding fracture systems. The lower-part of this water and dissolution and subsequent column would be sediment-laden, reflected in carbonate-sulphate erosion deposition of a breccia of marlstone and red clastic strata at the interface between the Macumber limestone and the overlying Upperton sulphates.

Following this relatively early hydration, later structural adjustments in the form of east-west strike-slip faulting affected the alteration and subsequent distribution of sulphate deposits in the area. The affect would have shattered sulphate beds adjacent faulted areas, making way for additional hydration of anhydrite and the subsequent recrystallization of pre-existing gypsum (*i.e.* crosscutting veins and solitary crystals of selenite; see Figure 20).

Figure 20. Recrystallized gypsum. Note spectacular stellate crystals of selenite in a matrix of alabastrine gypsum.

These faults may also have had a significant impact on the local thickness of the sulphate and related strata within the basin (*i.e.* the thickness of the Upperton sulphates in particular is considered to increase from the north to the south (see cross-sections on Map Plate 2000-31, Appendix B).

A third fault system is also recognized in the Hillsborough area. These structures are interpreted as north-south trending, normal faults affecting post-Windsor strata of the Mabou and Cumberland Group south of the Gray Brook basin.

Preliminary Deposit Evaluation:

Up until the early part of the 1980's gypsum deposits in Hillsborough area supported a local plaster and wallboard industry with a history of continuous production for almost 130 years. Millions of tons of gypsum were extracted from the areas underground mines and surface quarries established primarily along the southern limit of the Gray Brook basin ("main deposit") (see map inset A, Map Plate 2000-31, Appendix B). Although gypsum mining in former mine areas has been abandoned it is not known with certainty if the resource may in fact extend below some of the old working levels. Mining activity in these areas was generally discontinued when anhydrite was intersected in the floors of the workings. However, Bailey (1898) describes one *"permanent working"* where this was apparently not the case....

" *After going to a great deal of expense, work was abandoned at this point on account of the very large quantity of anhydrite encountered... Work was again undertaken at this place and the band of hard stone [anhydrite] was broken through when a very fine quality of gypsum, was exposed, and since that*

time this quarry has been in constant operation".

Given this scenario, inspection below the floors at some of the old quarries and underground mining operations might turn up additional gypsum resources.

A few areas adjacent some of the old workings have been drilled by Canadian Gypsum Co. Ltd., former holder of the mineral rights to the Hillsborough gypsum properties. It is unfortunate that other than location there is generally no recorded information regarding details of what was intersected. However, the fact that the company apparently drilled many holes in certain areas and chose not to establish extractive operations there, may be indicative of certain development restrictions (*i.e.* either no or limited thickness of gypsum; and/or excessive overburden thickness etc.)

Historically the distribution of anhydrite relative to gypsum throughout the Gray Brook basin has been problematic and imperfectly understood. Bailey's admission in the early part of the 20th century (Bailey 1906) that..."*no definite rule can be ascertained governing the mode of occurrence of the two rocks as regards either horizontal or vertical distribution"* often resulted in a "hit and miss" strategy in exploring the region.

The recognition that the distribution of anhydrite and gypsum may be structurally controlled by faults is an interesting revelation. Unfortunately it comes a bit late in assessing remaining gypsum and anhydrite resources in parts of the area. Over the past two decades alternative land uses (*i.e.* golf course, housing, wetland development, and tourism) have expanded into the sulphate area (s) that have largely remained unexplored. The potential for conflicting land use combined with various geological factors affecting the distribution of gypsum and anhydrite in the region place certain restrictions on the number of areas that might be considered as reasonable exploration sites and unqualified development alternatives. Given the above limitations there remain several areas worthy of further assessment.

Three proposed exploration areas (see Areas 1a, 1b, and 1c on map inset A, Map Plate 2000-31, Appendix B) are situated near the northern limit of the "Gray Brook" basin ("main deposit") and a few hundred meters northeast and just east of the former Sayre (gypsum) Quarry and underground mine site. Identified as 1a, 1b and 1c these areas generally occupy undeveloped forestland, and cover approximately 8,7 and 5 hectares respectively. Although Areas 1a and 1b are located just inside Hillsborough's village limit, all areas are generally remote from adjacent housing. These proposed exploration sites are situated less than 800 meters west and south of a paved secondary road. Areas 1a and 1c are also presently accessible via an old railway bed, cutting through the middle of 1a in an east-west direction, less than 100 m north of 1c. Area 1b is accessible just east of a trail adjacent the former Sayre Quarry site. This trail connects with a paved road (*i.e.* the Golf Course Road) about half a kilometer to the east.

Records indicate over 30 (Whaley 1997) holes were drilled east of and within 300 meters of the former Sayre gypsum operations. However, no details are provided. Much of this drilling is

targeted at the intervening area between Areas 1a and 1b. It is speculated that the sulphate resource may be limited to mostly anhydrite here, with recovery hampered by excessive overburden thickness. There remains however, the possibility that some gypsum may occur outlined in Areas 1a and 1b, adjacent east-west trending fault systems. This faulted terrain has not been thoroughly explored.

Area 1c occurs west of the former Sayre underground workings and straddles the same structural feature (fault) as does Area 1a. It also represents a potential exploration site where very limited exploration information is currently available.

Another relatively unexplored area with gypsum potential is area 2, (see Area 2 on map inset A, Map Plate 2000-31 Appendix B) comprising 40 to 50 hectares of lightly forested terrain in the west-central part of the "Gray Brook" basin. Area 2 is bounded to the west by a shallow canyon, the Whitehead Valley, drained by a north flowing tributary of Gray Brook. Several former gypsum quarries and associated underground workings mark its southern boundary. To the north it connects with the former Sayre (gypsum) Mine and remains relatively open to the east. The best access into Area 2 is via a few north-south trending hiking trails that cut through the proposed area. These trails connect with a abandoned east-west trending railway line a few hundred meters to the north, and link-up with a formerly mined area to the south. The southern part of the area is characterized by steep, north-sloping gradient, flattening out into a narrow valley setting of Gray Brook before gradually increasing in elevation further to the north.

A limited (7 holes), widely spaced drilling program was conducted many years ago across the southern portion of the proposed area. Overburden thickness from 3.5 to 13.7 m and sections of gypsum / anhydrite, (sulphate) up to 12 m thick was intersected locally. It is not known if this was the maximum thickness of sulphate here or if drilling was terminated at a depth determined by economic factors related to excessive mining costs. Regardless, the gypsum potential for.

Despite what appears to be discouraging results from limited exploration, Area 2 continues to be of interest as almost 85 % of the area remain virtually untested. It is also import to note that the area a series of north-south and east-west trending faults that may provide suitable structural settings (*i.e.* local hydration centers) for adjacent deposits of gypsum, particularly at points where the two opposing fault systems intersect each other.

It is also interesting to note that large tracts of the Area 2 are relatively remote from potentially competing land uses although its eastern limit remains within a few hundred meters of a golf course development.

A fourth area, Area 3, is (see Area 3 on map inset A, Map Plate 2000-31, Appendix B) recognized as yet another alternative site for gypsum exploration. It comprises about 12 hectares south of and adjacent to area 2 at the southwestern corner of the basin and immediately north and west of former

gypsum mining activities in the region. Although relatively remote from housing, the eastern limit of Area 3 is within 600 m of a golf course and parts of the property are used occasionally for recreational purposes (*i.e.* hiking, mountain biking). An interesting network of caves carved out of anhydrite/gypsum strata, are found adjacent the Whitehead Valley about 100 to 150 m northwest of the property. These caves, mapped in considerable detail (Arsenault et. al. 1997), are frequently visited by tourists and amateur adventurers and are said to provide a suitable habitat for bats during the winter months.

Past exploration in parts of Area 3 is limited to only a few drill holes reporting thick (10 to 15 m) overburden, underlain by 1.5 to 2 m of gypsum and unspecified thickness anhydrite. Although these results are not encouraging it is suspected that more massive gypsum deposits may be found proximal to northeast-southwest trending fault structures that are suggested to cut through the area.

The last area considered for (see Area 4 on map inset A; Map Plate 2000-31, Appendix B) exploration interest is situated at the western end of a series of abandoned quarries[9] and former underground workings, near the southwestern limit of the Gray Brook basin. Much of this proposed exploration site referred to as Area 4, probably has more potential as a source of primary anhydrite with gypsum considered as a secondary resource. Comprising almost 30 hectares, most of the proposed area occupies lands that were formerly extensively quarried for gypsum. The property is easily accessed by way of a network of roads that connect with a gravel road (Taylor Lane) at the eastern limit of former gypsum operations.

The anhydrite resources of area 4 have recently (1998) been the focus of a preliminary assessment by Mactaquac Mining Ltd. Mactaquac's exploration program, concentrated near former quarries, consisted of 675 m of core drilling (Figure 21), distributed among 13 holes, over 18 hectares [see Area 4 on

Figure 21. A drilling program (1998) has established the extent and quality of anhydrite reserves near Hillsborough, in southeastern New Brunswick.

[9] Although the quarried area is referred to as the "Tomkins Plaster Quarry" by Hamilton and Barnett (1970); Steeves (1951) and Whaley (1997) reveal that the area consisted of several smaller quarries and underground excavations. From west to east was the Milton, Smith, Bowman,, Small, Green and Gray quarries. Extensive underground workings were developed north of the Bowman (i.e. the Ham, Smith and Jones mines) and the Small and Green quarries (i.e. the D-51, North, West and South mines).

map inset A, Map Plate 2000-31, Appendix B). This work confirmed intersections of massive anhydrite up to 55 m thick establishing a basis for drill-indicated tonnage and grade of 18 million tonnes averaging 98.4 % anhydrite (Whaley 1998). Over burden thickness in the area were found to range from less than a meter to 13 meters (5-metre average).

Conclusions:

Sulphate deposits of gypsum and anhydrite are known to extend over 230 hectares a few kilometers west of the village of Hillsborough in southeastern New Brunswick. The area's gypsum resource has an exploration and development history spanning almost two centuries (Figure 22). Gypsum mining activities on the property came to an end in the early 1980's. Since that time limited gypsum exploration has been directed primarily in the vicinity of former mine sites. Most recently interest has been shown in assessing the anhydrite resource potential on parts of the property.

Recent studies indicate that two sulphate units occur in the Hillsborough area. The basal unit, the Upperton Formation, consists of a thick sequence of massive, anhydrite and secondary gypsum is overlain disconformably by a heterogenious sequence of selenitic gypsum anhydrite and minor dolomite and clastics referred to as the Lime-kiln Brook Formation. The brecciated nature of the Lime kiln Brook strata suggest it is probably the result of dissolution of more soluble evaporites (*i.e.* salt) and subsequent collapse onto the underlying Upperton sulphate.

The often problematic, spatial distribution of gypsum with respect to anhydrite in the area is considered linked to the structural development of

Figure 22. Workman extracting gypsum from a quarry near Hillsborough, N.B. ca.1911. *(source: Jennison 1911, p.97)*

the region. Thick deposits of high purity gypsum are considered to be the hydration product of primary anhydrite sometimes accompanied by subsequent episodes of recrystallization that developed adjacent to and at the intersection of water-bearing fault structures.

Following the termination of mining activities parts of the area underlain by sulphate deposits now support

alternative land uses. Respectful of these developments a few sites still remain as reasonable exploration options for additional gypsum and/or anhydrite resource assessment.

ACKNOWLEDGEMENTS:

The writer wishes to acknowledge with gratitude the contributions of Terry Leonard and Ken Mersereau, of the Geological Survey Branch's Mineral Deposits Section. Terry and Ken capably prepared most of the figures and the map plate that accompany this report. A special thanks to Gwen Martin for collaboration and providing several historical reference materials that were useful in reconstructing a chronology of events and issues that have affected Hillsborough gypsum industry throughout its long history. Thanks are also extended to Les Fyffe , D.V. Venugopal and Barbara Carroll of the Geological Surveys Branch for their review and constructive comments.

BIBLIOGRAPHY

ANNUAL REPORTS OF THE CROWN LAND DEPARTMENT (Government of New Brunswick). 1803, p. 29; 1810, p. 63; 1818, p. 24 and 40; 1892, p. vii; 1893, pp. C9-10; 1900, pp. C4-5; 1907, p. xxix; 1908, p. xxv; 1909, p. xxvii; 1910, pp. xxi-xxii; 1911, pp. xxi-xxii; 1912, pp. xxxiii-xxxiv; 1913, pp. xix-xx; 1914, pp. xvi-xvii; 1915, pp. xv-xvi; 1916, p. xix; 1917, pp. 31-32; 1918, pp. 31-33; 1919, pp. 65-67; 1920 pp. 96-97; 1921, pp. 50-51; 1922, p. 54; 1923, pp.60-61; 1924, p.59.

ANNUAL REPORTS OF THE DEPARTMENT OF LANDS AND MINES (Government of New Brunswick). 1925, p. 46; 1926, p. 61; 1927, pp. 52-53; 1928, p. 57; 1929, p. 55; 1930, p. 47; 1931, p. 38, 1932, pp. 41-42; 1933, p, 50; 1934, pp. 45-46; 1935, pp. 48-49; 1936, pp.54-55; 1937, p. 58; 1938, p. 64; 1939, pp. 66-67; 1940,p. 54; 1941, pp. 57-58; 1942, pp. 61-62; 1943, pp. 61-62; 1943, pp. 61-62; 1944, pp. 57-58; 1945, p.79; 1946,p. 28; 1947, p. 112; 1948, p. 119; 1949,p. 115; 1950, pp. 113-114; 1951, p. 49; 1952, p. 82; 1953, p. 87; 1954, p. 97; 1955, p. 91; 1956, p. 86; 1957, p. 92; 1958, p. 94; 1959, p. 95; 1960, p.87; 1961, p. 77, 1962, p. 80; 1963, p. 76; 1964, p. 85; 1965, p. 91; 1966, p.106.

ANNUAL REPORTS OF THE DEPARTMENT OF NATURAL RESOURCES (Government of New Brunswick). 1967, p. 124; 1968, p.108; 1969, pp. 108-109; 1970, p. 72; 1971, pp. 68-69; 1972, p. 71; 1973, p. 87 and 92; 1974, p. 120; 1975, p. 72 and 78.

ARSENEAULT, S.P., SCHROEDER, J., BÉRUBÉ, D. and ALBERT, R. 1997. The caves of southeastern New Brunswick (revised and supplemented). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 97-7, pp. 18-23.

BAILEY , L.W. and ELLS, R.W. 1878. Report on Lower Carboniferous belt of Albert and Westmorland counties, New Brunswick including "Albert shales". *In* Geological Survey of Canada, Annual Report for 1876-77, pp. 394 -395.

BAILEY, L.E. and JACK, E. 1876 The woods and minerals of New Brunswick: being a descriptive catalogue of the trees, shrubs, rocks and minerals of the province, available for economic purposes. *Note:* prepared for use at the Centennial Exhibition at Philadelphia in 1876, pp. 45-47.

BAILEY, L.W. 1865. Observations on the geology of southern New Brunswick, made principally during the summer of 1864. Printer of the Queen, Fredericton, N.B., p. 104.

BAILEY, L.W. 1898. The mineral resources of the Province of New Brunswick. Geological Survey of Canada, Summary Report 1897, Volume 10, Part M, pp. 85M - 98M.

BAILEY, L.W. 1906. The gypsum deposits of New Brunswick. Royal Society of Canada, Transactions Volume XII, Section IV, Second Series, pp. 3-14.

BISHOP, A.S. 1925. Selected Biographies: James Blight ESQ. *In* The Busy East of Canada, Volume 15, April-May, 1925, Nos. 9, 10, p. 107.

BISHOP, A.S. 1925. The Albert Manufacturing Company. *In* The Busy East of Canada, Volume 15, April-May, 1925, Nos. 9, 10, pp. 17-21.

BISHOP, A.S. 1925. The Hillsborough Plaster Company. *In* The Busy East of Canada, Volume 15, April-May, 1925, Nos. 9, 10, p. 22.

BROWN, D.F. 1986. Hillsborough property: Reconnaissance geology, historical compilation, rock sample survey and testing for gypsum content. Report for K.D.A. Whaley and B. Durling. Department of Natural Resources and Energy, Minerals and Energy Division, Mineral Exploration Report of Work, Assessment File 473343, p. 11.

CANADIAN MINERAL YEARBOOK, 1977 to 1982 (inclusive).

CHANDRA, J.J. 1986. Mineral production statistics 1899-1985, New Brunswick. Department of Forest, Mines and Energy, Mineral Resources Division, Open File Report 81-25, pp. 45-47.

COLE, L.H. 1913. Gypsum in Canada: its occurrence, exploration and technology. Canada Department of Mines, Mines Branch, No. 245, pp. 47-56.

COLE, L.H. 1930. The gypsum industry of Canada. Canada Department of Mines, Mines Branch, No. 714, pp. 24-29.

COSTE, E. 1887. Statistical report on the production value, exports and imports of minerals in Canada during the year 1886 and previous years. *In* Geological Survey of Canada Annual Report (New Series) Volume II, p. 36s.

DAVIS, H.A. 1950. An international community on the St. Croix, 1604-1930. University of Maine Studies, University Press, Orono, Maine, pp. 92-94.

ELLS, R.W. 1907. The geology and mineral resources of New Brunswick. Canada. Department of Mines, Geological Surveys Branch, No. 983, pp. 120-121.

GESNER, A. 1839. "Lubec plaster mill", in first report of the Geological Survey of New Brunswick. printed by Henry Chubb, Market Square, Saint John, p. 20

GESNER , A. 1847. New Brunswick: with notes to emigrants. Simonds and Ward, London, pp. 304-305.

GRAHAM, G.S. 1938. The gypsum trade of the Maritime Provinces. *In* Agricultural History. Agricultural History Society, a publication of the University of California Press (July 1938), Volume XII, pp. 209-233.

GUSSOW, W.C. 1953. Carboniferous stratigraphy and structural geology of New Brunswick, Canada. Bulletin of the American Association of Petroleum Geologists, Vol. 37, No. 7, pp. 1713-1816.

HALDIMAN PAPERS. 1767. Hugh Wallace to General Frederick Haldiman, New York, 19 December 1767. UNB MIC-Loyalist, (FC LMR.H3 F7 P3), Microfilm reel 9, Volume 21679, pp. 27-28.

HALIFAX REGIONAL MUNICI-PALITY. 1999. The Halifax Explosion. p. 4, www.region.halifax.ns.ca/community/explode.html); accessed 01/01/09)

HAMILTON, D.E. 1927. The Maritime Provinces. Toronto: W.J. Gage & Co. Ltd., pp. 378-379.

HAMILTON, J.B. and BARNETT, D. E. 1970. Gypsum in New Brunswick. New Brunswick Department of Natural Resources, Mineral Resources Branch, Report of Investigation 10, pp. 36-42.

HAMILTON, J.R. 1883. Saint John, and the province of New Brunswick: a handbook for travelers, tourists and business men. "published under the patronage of the Saint John Board of Trade, p.73.

HANNAY, H. 1902. New Brunswick (Canada): Its resources and advantages. Note: published by the Crown Land Department of the Province of New Brunswick, Fredericton, N.B., p. 62 and p. 129.

HAYES, W.H. 1929. The geography of New Brunswick. Unpublished M.Sc. thesis, Cornell University, Ithica, New York, p. 52.

HICKMAN, W.A. 1900. Handbook of New Brunswick (Canada): issued by the authority of the Crown Land Department. pp. 32-33.

INGALL, E.D. 1893. Mineral statistics and mines: Annual report(s) for 1890. *In* Geological Survey of Canada Annual Report (New Series) Volume V, Part II, 1890-91, p. 77s.

INGALL, E.D. 1898. Mineral statistics and mines: Annual report(s) for 1896. *In* Geological Survey of Canada, Annual Report (New Series) Volume IX, No. 625, p. 59s.

JENNISON, W.F. 1911. Report on gypsum deposits of the Maritime Provinces. Canada Department of Mines, Mines Branch, pp. 18-19 and pp. 93-96 and pp. 147-148.

JOHNSON, S. C. 1997. Amherst area (NTS 21 H/16 and part of 21H/09), Carboniferous geology maps, Albert and Westmorland counties, New Brunswick, Scale 1:50 000, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 97-1.

JOHNSON, S. C. 1997. Bedrock geology of Maringouin Peninsula, Cumberland Subbasin (NTS 21 H/09, 10, 15 and 16), New Brunswck. Scale 1:20000, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 97-1.

JONES, J. T., JONES, I. and WEST, J.W. 1997. Shadows of the past: historical-pictorial of Albert County, New Brunswick, Canada. Albert County Historical Society Inc., Hopewell Cape, New Brunswick, pp. 77-86.

KERNAGHAN, L. 1995. Halifax explosion. *In* The Canadian and World Encyclopedia (1999), McClelland & Stewart Inc.

KRAMM, H.E. 1912. Gypsum of New Brunswick. Canada Department of Mines, Geological Survey Branch, Summary Report for 1911, pp. 322-328.

LARRACEY, E.W., c. 1985. Chocolate river: a story of the Petitcodiac River from the beginning of habitation in the late 1600's until the building of the causeway at Moncton. pp. 152-153.

MacALPINE'S TOURIST GUIDE, 1897. Nova Scotia, New Brunswick and Prince Edward Island. J&A MacMillan, Saint John, N.B., p. 359.

McLEISH, J. 1910. Annual report of the Division of Mineral Resources and Statistics on mineral production of Canada during the calendar years 1907 and 1908. Monograph No. 58. Canada Mines Branch, p. 214.

McLEISH, J. 1914. Annual report on mineral production of Canada during the calendar year 1913. Monograph No. 320. Canada Mines Branch, p. 256.

McLEISH, J. 1916. Mineral production of Canada during the calendar year 1915. Monograph No. 426. Canada Mines Branch, p. 264.

McLEISH, J. 1918. Annual report on mineral production of Canada during the calendar year 1916. Monograph No. 474. Canada Mines Branch, pp. 240-241.

McLEOD, M.J. 1980. Geology and mineral deposits of the Hillsborough area, map area V-22 and V-23 (parts 21H/15E and 21H/15W). New Brunswick Department of Natural Resources, Mineral Resources Branch, Map Report 79-6, 35 p.

McLEOD, M.J. and JOHNSON, S.C. 1999. Alma (NTS 21 H/10). Bedrock geological compilation maps, Scale 1:50 000, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 99-25.

McLEOD, M.J. and JOHNSON, S.C. 1999. Hillsborough (NTS 21 H/15). Bedrock geological compilation maps, Scale 1:50 000, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 99-26.

McMULLEN, W.E. and WRIGHT, W.J. 1938. Non-Metallics of New Brunswick with special reference to diatomite. Canadian Institute of Mining and Metallurgy Transaction 41, pp. 374-377.

McNUTT, W.S. 1963. New Brunswick - A history: 1784-1867. MacMillan of Canada, Toronto, Ontario, pp. 136-140 and 173-175.

MINERAL RESOURCES BRANCH. 1978. New Brunswick's Mineral Industry-1977. New Brunswick Department of Natural Resources, Mineral Resources Branch, Topical Report 78-1, pp. 122-123.

MINERAL RESOURCES BRANCH. 1980. New Brunswick's Mineral Industry - 1979. New Brunswick Department of Natural Resources, Mineral Resources Branch, Open File Report 80-4, p. 97 and 110.

MINERAL RESOURCES BRANCH. 1981. New Brunswick's Mineral Industry - 1980. New Brunswick Department of Natural Resources, Mineral Resources Branch, Open File Report 81-25, p. 128 and 133.

MUNRO, A. 1855. New Brunswick, with a brief outline of Nova Scotia and Prince Edward Island..... Halifax, N.S.: Richard Nugent, p. 227.

NEW BRUNSWICK ROYAL GAZETTE, 1820. Item: Saint John, May, 27. p. 3.

NEW BRUNSWICK ROYAL GAZETTE, 1820. Item: From the St. John Star. p. 3.

NORMAN, G.W.H. 1932. Stratigraphy of the Stoney Creek oil and gas field, New Brunswick. *In* Oil and Gas in Eastern Canada. Canada Department of Mines, Geological Survey, Economic Geology Series, 9, pp. 167-173.

NORMAN, G.W.H. 1941. Hillsborough map sheet, Albert and Westmorland counties, New Brunswick. Geological Survey of Canada, Map 647A (with marginal notes).

RUBENSTEIN, D. Drilling for dollars. The Moncton Times & Transcript, June 24, 1998, Section D. p. D1.

SCLANDERS, I. 1949. Industrial New Brunswick-Where plaster comes from. *In* Telegraph Journal, March 29, 1949.

ST. PETER, C. 1989. Geology of the Albert Formation, Moncton Subbasin. Sheet A (parts of 21H/15 and I/2) and Sheet B (part of 21 H/15), Scale 1:20 000, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plates 89-104A and 89-104B.

ST. PETER, C. 1996. Alma area (NTS 21 H/10). Carboniferous geology maps, Albert and Westmorland counties, New Brunswick, Scale 1:50 000. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 97-10.

ST. PETER, C. 1996. Sawmill Creek-Demoiselle Creek area, Carboniferous geology maps, Albert and Westmorland counties, New Brunswick, Scale 1:20 000. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 96-51F.

ST. PETER, C. 1996. Sheet A (parts of 21 H/15 and 21 I/2) and Sheet B (parts of 21 H/15). Geology of the Albert Formation, Moncton Subbasin. Scale 1:20 000, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plates 89-104A & 89-104B.

ST. PETER, C. and JOHNSON, S. C. 1997. Hillsborough area, Carboniferous geology maps, Albert and Westmorland counties, New Brunswick, Scale 1:50 000. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 97-8.

STEEVES FAMILY REGISTER, 1988. The early history of Hillsborough's gypsum industry. Issue 74, April-May 1988, Hillsborough, N.B., pp.1-5.

STEEVES, H.D. 1991. Borehole maps, Canadian Gypsum Co. Ltd., Hillsborough, N.B. (1951), Scale: 1 inch equals 100 feet, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plates 91-34A (Sheet No. 1A); 91-34B (Sheet No. 1B); 91-34C (Sheet No. 2A); 91-34D (Sheet No. 2B).

STEEVES, H.H. 1924. The story of Moncton's first store and storekeeper. J&A McMillan, Saint Jon N.B., pp. 92-95.

STEEVES, M. 1980. Fundy folkore: (History of Hillsborough's gypsum industry). pp. 50-55.

SUND, J.O. 1958. Origin of New Brunswick gypsum deposits. Unpublished MSc thesis, University of New Brunswick, Fredericton, N.B. pp. 38-60.

SUND, J.O. 1959. Origin of New Brunswick gypsum deposits. Canadian Institute of Mining and Metallurgy Transactions 62, pp. 395-400; and Canadian Institute of Mining and Metallurgy Bulletin 571, pp. 707-712.

TELEGRAPH JOURNAL 1980. Hillsborough loses gypsum plant: villagers face "grim " New Year. December 17, 1980.

TELEGRAPH JOURNAL 1982. Former gypsum company land purchased: new Albert Museum Center ahead. March 2, 1982.

THE DAILY GLEANER 1980. Gypsum plant closes – day called worst in Hillsborough's history. December 20, 1980.

THE DAILY GLEANER. 1998. Minto job details today. April 5, 1998.

THE DAILY GLEANER. 1998. Province hopes to cash in on coal. April 7, 1998.

THE MONCTON TIMES & TRANSCRIPT 1981. Province seeking answers from Canadian Gypsum Co. September 9, 1981.

THE MONCTON TRANSCRIPT. 1930. Albert Manufacturing Co. property changes hands. September 9, 1930.

THOMAS, L.O. 1930. The Province of New Brunswick, Canada: Its natural resources and development. Department of the Interior, Ottawa, Canada, pp. 92-93.

VAN DE POLL, H.W. 1973. Carboniferous stratigraphy and sedimentology of the Chignecto Bay area, southern New Brunswick. *In* 65th New England

International Geological Conference, Field Guide to Excursions, N. Rast (editor). Department of Geology, University of New Brunswick, Fredericton, New Brunswick, pp. 21-33.

WEBB, T.C. 1997. Carboniferous limestone of New Brunswick: geology and development potential. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 97-7, pp. 35-39.

WEBB, T.C. 1977. Gypsum and related deposits of New Brunswick. New Brunswick Department of Natural Resources, Mineral Resources Branch, Topical Report 77-6, pp. 30-31.

WEBSTER, J. C. 1934. Acadia at the end of the 17th century ....., New Brunswick Museum, Saint John, N.B. p. 130.

WHALEY, K.D.A. 1988. Hillsborough Group: Drilling, geology, rock sample survey, and testing for gypsum and salt content. Report for B. Durling, Department of Natural Resources and Energy, Minerals and Energy Division, Mineral Exploration Report of Work, Assessment File 473490, p. 9.

WHALEY, K.D.A. 1990. Hillsborough Property: Assessment drill report. Report for Eastern Gypsum Inc., Department of Natural Resources and Energy, Minerals and Energy Division, Mineral Exploration Report of Work, Assessment File 473877, p. 3.

WHALEY, K.D.A. 1995. Hillsborough Gypsum Quarries. Report for Mactaquac Mining Ltd., New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Mineral Exploration Report of Work, Assessment File 474678, p.13.

WHALEY, K.D.A. 1997. Survey of New Brunswick Gypsum. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 97-12, pp. 8-10.

WHALEY, K.D.A. 1998. Hillsborough Property, Albert County, 21H/15. Report for Mactaquac Mining Ltd., Department of Natural Resources and Energy, Minerals and Energy Division, Mineral Exploration Report of Work, Assessment File 475146, p. 3.

WHITE, A. 1998. Poor prospects. Can the mining industry survive its darkest hour? New Brunswick Business, Fall issue, 1998, pp. 69-71.

WRIGHT, W.J. 1922. Geology of the Moncton map area. Geological Survey of Canada, Memoir 129, 69p.

APPENDIX A

Compiled chemical analysis of gypsum and anhydrite samples from the Hillsborough area of southeastern, New Brunswick (1898-1995)

Appendix A. Compiled chemical analyses from gypsum and anhydrite samples (outcrop) from the Hillsborough area, southeastern New Brunswick.

Source	Wt %										Remarks
	Insol.	Fe_2O_3	Al_2O_3	SiO_2	CaO	MgO	SO_4	H_2O	NaCl[c]	$CaSO_4 \cdot 2H_2O$	
Bailey (1898)	-	trace	0.25	0.25	32.45	trace	46.38 (SO_3)	21.05	-	99.88	Sample location unknown
Jennison (1911)	-	0.18		-	32.04	trace	46.30	20.40	-	97.48	Sampled from quarries in the Hillsborough area. Exact locations unknown.
	trace	0.18		-	36.69	trace	49.73	12.15	-	58.06	
	0.40	0.60		-	32.92	-	46.36	19.55	-	93.42	
	0.80	1.80		-	32.72	-	45.24	20.17	-	96.38	
	trace	-		-	33.28	-	46.36	20.65	-	98.68	
	-	0.40		-	33.00	-	46.32	20.45	-	97.72	
	trace	-		-	33.00	-	46.80	20.80	-	99.39	
	-	trace		-	32.60	-	46.60	20.90	-	99.87	
	-	-		-	33.00	-	46.64	20.90	-	99.87	
	-	-		-	32.92	-	46.40	20.72	-	99.01	
Cole (1930)	0.92	0.08	-	0.06	33.17	0.06	44.18	19.17	-	91.60	Sampled from former King Quarry area
Brown and Whaley[10] (1986)										55	All samples immediately west of former New Mine area
										70	
										80	
										92	
										40	
										72	
										72	
										79	All samples from the former Sayre Quarry area
										83	
										100	
										100	
										66	All samples from the east "wall" of Whitehead Valley
										62	
										73	
										51	
										53	
										48	
										82	
										86	

[10] % gypsum is a guide, determined by "water loss test" (Brown and Whaley 1986, p. 6) in a " rough field laboratory" setting.

Appendix A. (con't). Chemical analyses from gypsum and anhydrite samples (outcrop) from the Hillsborough area, southeastern New Brunswick.

Source	Wt %										Remarks
	Insol.	Fe_2O_3	Al_2O_3	SiO_2	CaO	MgO	SO_4	H_2O	NaCl[c]	$CaSO_4 \cdot 2H_2O$	
Brown and Whaley[11] (1986) con't										86	All samples from the former Tomkins/Small quarries and D-51, South , West and North mine
										42	
										43	
										77	
										64	
										100	
										83	
										39	All samples west of former Tomkins Quarry area (*i.e.* Back Quarry area)
										72	
										92	
										68	
Whaley (1988 and 1997)								18.90	.023	95.2	All samples from former King Quarry area
								18.20	.035	87.0	
								18.17	.048	86.8	
								19.22	.039	91.9	
								18.78	.039	89.8	
								18.49	.028	88.4	
								15.24	.068	72.9	
Whaley (1995)										47.36	All samples west of former Tompkins Quarry area (*i.e.* Back Quarry area)
										77.29	
										94.84	
										94.21	
										94.47	
										87.54	
										93.96	
										94.20	All samples from former Tomkins/Small quarries and D-51 mine areas
										95.23	
										94.90	
										96.87	
										94.11	
										94.92	
										95.39	
										94.05	
										95.33	

[11] % gypsum is a guide, determined by "water loss test" (Brown and Whaley 1986, p. 6) in a "rough field laboratory" setting.

APPENDIX B

WEBB, T.C. 2000. Carboniferous geology and gypsum / anhydrite resources of the Hillsborough area (part of NTS 21H/15), Albert County, southeastern New Brunswick. **Map Plate 2000-31**, Minerals and Energy Division, New Brunswick Department of Natural Resources and Energy.